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Some Observations on the Natural History of Tadpoles of *Rhinophrynus dorsalis* Dumeril and Bibron

L. C. Stuart

During early July, 1958 I had an opportunity to revisit Tikal, El Petén, Guatemala which I had studied two years previously (Stuart, 1958). In the interim between my earlier and later visits the natural *aguada* (water-hole) at the main campsite had been enlarged and deepened by bulldozers and a new *aguada* had been dug early in 1958 at the northern end of the airstrip about one kilometer north of the camp.

These two *aguadas* were quite different in their physical characteristics and presumedly in their chemical and biotic features as well. The campsite basin was surrounded in part by forest and in part by the lawns and scattered trees of the camp area. High mounds of stiff clay thrown up by the deepening operations divided the once-single *aguada* into four separate pools. These were said to be 3-4 m. in depth. Sparse aquatic vegetation grew along the original margins of the *aguada*. The water, though not muddy, was stained so dark a brown that visibility was restricted to about a meter depth at most. No water temperatures were taken. The airstrip *aguada*, which for reasons to be made apparent was examined in more detail, was roughly circular in outline, about 25 m. in diameter and with banks or dikes of stiff, gray clay that rose 1-3 m. above the water surface. These banks comprised the material that had been removed to construct the basin that was somewhat more than 3 m. deep. The basin itself dropped off sharply from the *aguada* margin. The water was brown stained though not to the extent of that of the campsite water-hole and visibility extended to possibly 2 m. depth. The surface temperature was 33°C on the morning of July 7. The terrain surrounding this *aguada* had been completely cleared for a distance of about 50 m. from the water's edge and only a few, low plants had begun to take root. The basin itself was devoid of other than microscopic vegetation. Of the two *aguadas*, that at the campsite may be presumed to have been the more productive. Certainly a natural water-hole of some age as compared with the newly-dug airstrip basin warrants such a conclusion.

Around and within the campsite *aguada* recently metamorphosed individuals of *Bufo valliceps, Leptodactylus melanonotus, Smilisca baudini,* and *Hyla microcephala martini* were secured as were the tadpoles of *Rhinophrynus dorsalis, Smilisca baudini, Hyla microcephala martini* and *Microhyla elegans.* Adults of *Phyllomedusa callidryas, Hyla loquax, Hyla microcephala martini, Rana pipiens* and *Bufo valliceps* were common but not abundant around the *aguada* margin and *Phyllomedusa callidryas* was still engaged in breeding activities. In contrast, the airstrip *aguada* supported only tadpoles of *Rhinophrynus dorsalis* while around its margin were observed only a few half-grown individuals of *Rana pipiens.*

My own observations and collections were made July 4-10. Following my departure from Tikal, Mr. Richard Adams, who was in charge of the summer archeological studies in 1958, overseered the collecting and preservation of samples of *Rhinophrynus* tadpoles from the airstrip *aguada* at weekly intervals through August 17. To him and to my field assistant whom he directed I am indebted for the excellently preserved series of tadpoles now contained in the collections of the Museum of Zoology, University of Michigan. Owing to the more open nature of the airstrip *aguada* as well as to the better visibility afforded by the less deeply stained water, my observations were restricted largely to that basin. I have at hand, however, comparative samples secured by me from the camp *aguada.*

Behavior.—Within the airfield *aguada* (and insofar as could be determined, in the camp *aguadas* as well) the *Rhinophrynus* tadpoles were never observed swimming about singly, but always occurred, rather, in tightly massed aggregates of varying sizes. These aggregates—my field assistant referred to them as *nubes* (clouds) which, indeed, they appeared to be—were not spherical or "ball-like" in form as described by Taylor (1942:37) but were somewhat flattened or disc-like. One that was estimated to be about 25 cm. in diameter appeared to be about 10 cm. in depth. The smallest of these aggregates was about 10 cm. in diameter and it was estimated that it was composed of about 50 individuals. Laboratory measurements, however, suggest that this could have been a low estimate. It was found that tadpoles collected on the day during which the observations were made have a mean volume of 1.0 cc. If the 2.5 ratio of depth to diameter obtained in these small aggregates, each tadpole would have occupied about 4.0 cc. of space within the aggregate. The tadpoles appeared to be more tightly clustered than that figure would suggest. The largest aggregates were estimated to measure about 1.0 m. in diameter but these larger masses were infrequent. Owing to refraction the depth of such a mass could not be judged. Such an aggregate, however, must have been composed of literally thousands of individuals. Because of limited vision no estimate of the number of aggregates within the *aguada* could be made.

Within each aggregate the tadpoles moved slowly, generally in a counter-clockwise direction. The schools moved more or less randomly in and out from the *aguada* margin though they never entered water less than about a meter in depth, and the upper surface of the aggregates, except as described below, maintained a position about 0.3-1.0 m. below the water surface. Though movement from deeper to shallower water appeared to be random, all aggregates slowly circled the *aguada* in a counter-clockwise direction. The rate of movement of the individual schools was measured at about 1.0 m./min.

The aggregates did not retain their identity completely, for occasionally two small schools were observed to join together to form a larger mass. During this merging of two schools no disorganization within the joining masses was noted. Rather the individuals within each aggregate simply "blended" into the whole and the entire school continued its movement through the water without interruption of any sort. Though no aggregates were observed to break up into smaller schools, such, by fiat, must have taken place. Occasionally the larger aggregates broke their circular form as groups of individuals moved out from the main mass in the form of long, amoeboid-like pseudopods. These, however, were always "reabsorbed" by the main mass which appeared to overtake the outlying individuals and the aggregate would assume the more regular form. Though a school would break up momentarily as my improvised dip-net (a sherd-basket attached to a long pole) went into action, it always reformed quickly following such a disturbance. Captured individuals upon being released at the *aguada* margin swam about in a confused manner for some few moments before moving into deep water to join a passing school.

At irregular intervals any single school would be thrown suddenly into a state of great activity. From my few observations it was impossible to determine what stimulus triggered the following events. A school would appear to erupt in its center, and a column of tadpoles would swim swiftly to the surface. As the surface of the water was approached the column would fan out in much the same manner as an atomic cloud forms. The tadpoles would break the surface momentarily and at the same instant, judging from the sun glistening on the silvery peritoneum beneath the thin, transparent body wall, apparently turned belly up. Having broken the surface the tadpoles swam swiftly downward in a somewhat broken column to join the parent mass always along its trailing edge. Whether or not all individuals within the aggregate participated in this surfacing behavior could not be determined.

At what time during the early tadpole stage the gregarious habit is initiated is, of course, unknown. I was informed, however, that, though schools were still present in the *aguada* on August 10 just

before metamorphosis began, all had disappeared by August 12 when only metamorphosed individuals were obtained (see below).

Feeding habits.—In a recent paper Starrett (1960:7-8) has recorded cannibalism as a feature observed in a series of *Rhinophrynus* tadpoles from the vicinity of Tehuantepec, Mexico. In an effort to determine if this habit is general throughout the range of this toad, stomach contents were examined in tadpoles of various sizes in the Tikal series. Although only 12 intestinal tracts were studied (materials from both *aguadas* represented), these examinations were made upon individuals ranging in length from 17.0 mm. (collected July 6, 1958) to 25.0 mm. (collected August 10, 1958) as well as upon a metamorphosed individual with a considerable remnant of tail. These compare favorably in size with those studied by Starrett who gave a maximum total length in her series of 50.0 mm. (tadpoles in the Tikal series of 25.0 mm. body length have a total length of 60.0 mm.) In no instance did I observe any evidence of cannibalism. In fact if the series studied is at all typical of individuals inhabiting the Tikal *aguadas*, it must be concluded that the tadpoles are strictly filter-feeders. The bulk of the material in the intestinal tracts consisted of microscopic blue-green algae (*Cyanophyta*), green algae, (*Chlorophyta*) and some diatoms (*Chrysophyta*). Several gastrotrichs were noted in one intestine, a microscopic oligochaete in another, and a number of microscopic crustaceans (probably very tiny copepods) in yet another. Judging by the amount of intact algal material found in the lower intestine, the digestive processes of these tadpoles does not appear to be too efficient.

Growth.—Although samples of the tadpole population of the airstrip *aguada* were secured over a period of six weeks, little growth and development data are available owing to the obviously incomplete sampling methods employed. I suspect that my field assistant merely dipped up a bottle-full of individuals from the first aggragate within his reach and considered his contribution to science completed. Most of the samples contained 50-75 individuals.

Nevertheless a few data are suggestive. According to Mr. Adams the rains broke at Tikal about mid-May in 1958. Although the airstrip *aguada* probably did not receive much water during the first rains, it certainly presented conditions favorable for amphibian breeding by May 20, a night on which Adams recorded a tremendous frog chorus at the camp *aguada*. Since *Rhinophrynus* is known to be an early breeder (Stuart, 1935:35), it may be assumed that it was certainly represented in that chorus at the camp *aguada* and was not improbably also breeding at the same time at the airstrip *aguada*. It may be assumed, therefore, that tadpoles secured from the campsite July 9 were probably seven weeks from the time of egg deposition. Those taken July 6-8 from the airstrip

site were certainly not more than a week younger. Table 1 presents data on size in the samples secured at various time intervals.

It will be noted, first, that during the assumed 6-7 week period following egg deposition in the airstrip *aguada* the tadpoles attained a mean body length of 18.0 mm. Growth from that time on decelerated and in the three weeks following July 7 an increase in mean body length of only 5.0 mm. was noted. Second, in the two weeks July 27-August 10 there appeared to be no increase in mean body length. Third, the maximum body length attained by the tadpole before metamorphosis appears to be about 25.0 mm.

Hind-leg buds are first visible in individuals of about 20.0 mm. body length and at the same time fore-leg buds are visible through the thin body wall high on the dorsal side. Hind legs are perfectly formed in individuals with a body length of 22.0 mm. An individual secured on August 10 had a body length of 22.5 mm. and hind legs 9.5 mm. in length, yet in this individual there was no evidence that the fore legs were about to break through the body wall.

The decrease in size or at least in body length following metamorphosis appears to be associated with change in body shape. Upon metamorphosing the young frog assumes a more globose shape than is characteristic of the tadpole stage.

With regard to the much larger size of the camp *aguada* population as compared with the airstrip *aguada* population on approximately the same date (July 9 and July 7 respectively), I am inclined to view this phenomonon as associated with available food rather than difference in age. Certainly during the early life of the airstrip *aguada* population, the water of the newly constructed *aguada* must have been relatively sterile in comparison with that of the very old natural *aguada* at the campsite.

Discussion.—Schooling or aggregation of tadpoles is known to occur in a number of salientian species and has been described extensively in *Scaphiopus* (Ball, 1936; many accounts by Bragg, especially 1948; Richmond, 1947). Taylor (*op. cit.*) and Starrett (*op. cit.*) have noted the same behavior in tadpoles of *Rhinophrynus*. Both Richmond (*op. cit.*) and Bragg (1946) have essayed interpretation of aggregation in *Scaphiopus*, suggesting both crowding and facilitation of feeding as well as a complex of factors as the stimulating agents. Starrett (*op. cit.*), who observed *Rhinophrynus* tadpoles in the beam of a flashlight, inferred that aggregation may have been merely a positive phototaxic response. From the foregoing presentation it would appear that crowding, feeding and response to light may be eliminated as contributory to *Rhinophrynus* aggregation. Certainly on the basis of the few observations herein described I would not even hazard a guess as to casual agents.

One feature that may be novel in my observations is the surfacing behavior. This may have been the same behavior referred

to briefly by Taylor (*op. cit.*:37) in his notation of the ball-like mass of tadpoles "coming to the surface and submerging as if the mass was revolving." Ball (*op. cit.*:358) also may have observed a similar behavior in tadpoles of *Scaphiopus h. holbrooki* in describing what seemed as if "every tadpole appeared to be trying to climb on top of the mass, those at the thinner margins dashing upon those in the center and forcing them downward and outward." Richmond, too, in his study of the same species of *Scaphiopus* may have seen this same behavior, for he notes (*op. cit.*:58) that "the individual in one of these groups feeds along the bottom, rises to the top for a bubble of air, and then tries to return to the bottom. At the same [time] those individuals on the outer edges of the groups keep forcing their way into the center, . . ." However, none of these observations suggests the periodic and rigid pattern of the surfacing behavior herein described. Again my meager data preclude all possibility of even suggesting interpretation of this behavior.

Apparent absence of the cannibalistic habit in the Tikal populations as opposed to almost universal cannibalism in larger individuals of the population from Tehuantepec, Mexico noted by Starrett (*op. cit.*) may merely mirror contrasting environmental conditions. As indicated by examinations of stomach contents, the Tikal *aguadas* appear to support an extremely rich microflora. The Tehuantepec pools, with which I am personally familiar, present very different conditions. These roadside "tanks" are extremely muddy and light for photosynthesis certainly can not penetrate to more than a couple of inches depth. As a result the microflora of such pools may be relatively poor. This suggestion is borne out by microexamination of intestinal tracts taken from individuals in the Starrett collections. Some few fragments of both diatoms and green algae were noted in both small and large individuals, but such material was sparce in the extreme. It would appear that the Tehuantepec population was actually "driven" to cannibalism through failure of the food supply, a condition that has been described by Richmond (*op. cit.*:63-64) for *Scaphiopus h. holbrooki.*

But even assuming that *Rhinophrynus* tadpoles are normally cannibalistic in spite of sufficient plankton, yet another factor might account for absence of cannibalism in the Tikal populations. At that locale no well-marked size classes of tadpoles were observed. In contrast, two very distinct size classes are present in the collection from Tehuantepec: one measuring less than 10.0 mm. body length and another measuring about 20.0 mm. body length. As a result it would seem quite possible for an 18.0 mm. tadpole, for example, to engulf an 8.0 mm. tadpole whereas, uitilizing extremes noted in the Tikal populations, it would seem almost impossible for a 25.0 mm. tadpole to engulf one of 15.0 mm. body length. It is true that small (5.0 mm.) tadpoles of both *Microhyla elegans* and *Leptodac-*

tylus melanonotus were present in the campsite *aguada* at Tikal. But these latter appeared to be restricted to the very shallow *aguada* margin at depths which *Rhinophynus* tadpoles were not observed to enter. Furthermore, to my knowledge, the shallow waters of the Tehuantepec tanks would very probably bring tadpoles of *Rhinophrynus* into contact with those of other species, thus permitting the predation noted by Starrett.

TABLE 1.—Body lengths (in mm.) of the tadpoles of *Rhinophrynus dorsalis* on various dates at the Tikal *aguadas*.

1958	Locale	Min. Body Lg.	Max. Body Lg.	Mean Body Lg.
July 7	Airstrip *aguada*	15.5	21.0	18.0
July 9	Campsite *aguada*	16.0	25.0	21.0
July 13	Airstrip *aguada*	14.0	20.5	17.5
July 27	"	16.0	25.0	23.0
August 10	"	15.5	24.5	23.0
August 17	"	16.5	19.5	18.0
	all metamorphosed			

LITERATURE CITED

BALL, STANLEY C. 1936. The distribution and behavior of the Spadefoot Toad in Connecticut. Trans. Conn. Acad. Arts and Sci., 32:351-379, pls. 14-15.

BRAGG, ARTHUR N. 1946. Aggregation and cannibalism in tadpoles of *Scaphiopus bombifrons* with some general remarks on the probable evolutionary significance of such phenomona. Herpetologica, 3, 1946:89-97.

———. 1948. Additional instances of social aggregation in tadpoles. The Wasmann Collector, 7, 1948:65-79.

RICHMOND, NEIL D. 1947. Life history of *Scaphiopus holbrookii holbrookii* (Harlan). Part I: Larval development and behavior. Ecology, 28: 53-67.

STARRETT, PRISCILLA. 1960. Descriptions of tadpoles of Middle American frogs. Misc. Publ. Mus. Zool., Univ. Michigan, 110:37 pp., 33 figs., 1 pl.

STUART, L. C. 1935. A contribution to a knowledge of the herpetology of a portion of the savanna region of central Petén, Guatemala. Misc. Publ. Mus. Zool., Univ. Michigan, 29:56 pp., 4 pls., 1 fig., 1 map.

———. 1958. A study of the herpetofauna of the Uaxactun-Tikal area of northern El Petén, Guatemala. Contrib. Lab. Vert. Biol., Univ. Michigan, 75:30 pp.

TAYLOR, EDWARD H. 1942. Tadpoles of Mexican Anura. Univ. Kansas Sci. Bull., 28:37-55, 3 pls.

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The Behavior and Comparative Developmental Rates in Nature of Tadpoles of a Spadefoot, a Toad, and a Frog.

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Although it is well known that spadefoot embryos and tadpoles have a rate of development intrinsically faster than that of most other Amphibia, few data comparing their rates with those of members of other genera have been published (Trowbridge and Trowbridge, 1937; Bragg, 1950, 1954, 1959; Bragg and King, 1961). In the spring of 1960, an exceptional opportunity to make such a comparison presented itself, the results of which are here reported. In addition, some further notes are given on breeding adults; and observations on aggregational behavior of the spadefoot tadpoles are included.

On the night of April 13, following an afternoon rain of approximately 1.5 inches, a breeding congress of Salientia, including *Scaphiopus holbrooki hurteri* Strecker, *Bufo terrestris charlesmithi* Bragg and *Rana pipiens berlandieri* Baird was formed. For convenience I shall henceforth refer to them as spadefoots, toads, and frogs respectively, since these are the only forms involved.

The breeding site was pool Ks (Bragg, 1959), a small, shallow, nearly circular, clear, woodland pool on a hilltop 15 miles east of Norman, Cleveland County, Oklahoma. It is partly shaded by small oak trees, and its bottom is heavily leaf-strewn. The water is stained a light amber color. No vegetation grows from the bottom of the pool, but some algae (principally unicellular forms) occur. Immediately after rains, the water is turbid, how much so depending upon the amount and especially the rate of runoff into the pool from the surrounding land. During the exceptionally rainy spring of 1957, the pool was turbid for a long period (Bragg, 1959). In 1960, however, it was only slightly turbid at first, but cleared within a few days and remained so during my period of study.

Only one spadefoot call was heard in the breeding congress on April 13, but at nine o'clock the next morning two mated pairs were seen in the pool and at least one clutch of spadefoot eggs had been laid during the night. Another 0.5 inch rain had fallen between my two visits, and this probably had stimulated the animals to greater breeding activity, since it is unusual to find female spadefoots still in pools this late in the morning after nights of breeding. One male left the pool while I was there, apparently having just finished his breeding activity. I estimated the amount of breeding as one clutch of eggs laid during the night and two more produced sometime that day, three clutches in all, one laid several hours before the other two. The tadpoles later substantiated this estimate. No adult frogs were seen, but one clutch of their eggs had been pro-

duced during the night. Calling males, mated pairs, and eggs of the toads were present.

One cross-mated pair was seen, a male spadefoot clasping a female toad. The pair was first noticed as it came to the surface. The animals immediately submerged again and soon became separated under water. It is unfortunate that I could not see well enough to determine whether the male voluntarily released the female; it is difficult to understand how otherwise she could have escaped him.

As this female toad (immediately after escaping the spadefoot) surfaced about three feet off shore, a male toad at the water's edge started calling. Before he had finished his first trill, the female swiftly oriented toward him, swam rapidly to him in a straight line and was clasped without prior physical contact. In fact, a split second before she reached him, the male stopped his call and faced about to meet her. This, therefore, is another clearcut observation to add to the few definitely known instances of the attraction of the female by a male's call.

The pool was visited every few days to watch the development and behavior of the tadpoles. The spadefoot eggs had all hatched on the third day, the toads' on the fifth and the frogs' on the seventh. Growth rates were the same as usually seen in each of the species as judged by former experience; therefore, no detailed measurements seemed necessary.

On April 21, 6-7 days from the egg stage, some of the spadefoot tadpoles were noted in three small feeding aggregations. The aggregated tadpoles appeared to be feeding upon suspended particles (perhaps unicellular algae) in the water. Two days later, nearly all spadefoot tadpoles in this pool were in similar but larger social feeding aggregations and thereafter were never observed to be otherwise till nearing metamorphosis. No toad or frog tadpoles were ever seen aggregated here, thus showing again that the behavior of the larval spadefoots is intrinsically different from that of the other species (Bragg, 1944, 1959).

When the tadpoles were about 12 days old, I collected several hundred spadefoot larvae from an aggregation. These were divided into two approximately equal groups, one being added to an aquarium in which two African frogs, *Xenopus laevis laevis*, had long been kept. The other was placed in another aquarium containing small fish (guppies). Since the water in each aquarium was bright green with planktonic, unicellular algae, the object was to confirm the impression received at the pool that these tadpoles could and would feed on suspended particles.

The result was rather unexpected. Those with the fish apparently paid no attention to the algae and practically none survived. However, it took the others less than a half-hour to clear the water

of its green color and many eventually metamorphosed normally. The two solutions must have differed in many ways; therefore, the observations only show that under some conditions spadefoot tadpoles readily feed on suspended algae and under other conditions they do not.

At 1:30 p.m. May 19, most of the spadefoot tadpoles were in two large aggregations, although a very few stragglers were present at the shoreline. In circling the pool twice, I found only five individuals outside of these groups. These two aggregations presented different types of behavior. The first group was a typical social-feeding aggregation as commonly seen. All tadpoles in it had enlarging hind legs and other characteristics expected in spadefoot tadpoles about two days prior to metamorphosis. The second aggregation presented phenomena which I had never seen before in twelve seasons of watching such groups and which apparently have not previously been reported.

This second aggregation contained approximately equal numbers of tadpoles of two age groups. The younger ones were essentially like those in the large feeding aggregation a few feet away. These formed a social-feeding subaggregation just under the water surface where they behaved as though feeding on floating particles. The older tadpoles were clustered *directly below the younger ones.* All tadpoles in this lower sub-aggregation had four legs, all were lighter colored than those above them, and all had the dorsal pattern characteristic of the adults. Hence, they were distinguishable at a glance from the tadpoles of the younger group. Their behavior was exactly like that of those in metamorphic aggregations as seen many times in other years (Bragg, 1944, 1950, 1950b, 1959) from which emergence from the water is to be expected within a few hours. They were milling about slowly and were not feeding.

The phenomenon here referred to as metamorphic aggregation actually represents an aggregation of individuals which have completed their feeding and are in the final stages of metamorphosis. Such an aggregation will hereafter be referred to as a metamorphic aggregation.

In some respects, one might consider this as representing two separate aggregations, a socially feeding group happening by chance to lie directly above a metamorphic aggregation. But there was a slight amount of mixing at the junction of the two groups, and furthermore the older tadpoles were individually passing up through the aggregation above them to gulp air at the surface and then swimming swiftly and directly downward to rejoin their own subgroup. It was clearly evident that the individuals in each group were reacting to the presence of others in their own subaggregation and paid no attention to those in the other. If any-

one has lingering doubts about the social nature of some feeding aggregations and all metamorphic ones in this spadefoot species, these observations should dispel them, since all elements of behavior described were clearly seen and the relationships between them were maintained for a full half hour of continuous observation (*c. f.*, Richmond, 1947; Bragg, 1950b; and Bragg and King, 1961).

The pool was filled with tadpoles, almost suggesting a large bowl of tadpole soup. Accordingly, toad and frog tadpoles frequently passed through the aggregations of spadefoots, but none joined them, merely continuing on their way. When several toad and frog tadpoles passed through at the same time, the aggregation was at times disturbed slightly by their movements, but the spadefoots merely moved together again, *each type with its own subgroup.*

Since it was obvious that all of the spadefoot tadpoles in the pool had come from at least two and probably three clutches of eggs, one laid several hours before the other(s), two age-groups were to be expected, a smaller number of older ones, as found. Because of this, I thought it likely that this "double" aggregation was almost certainly formed as follows: up to a few hours before my observations were made, tadpoles reacting to each other had been in two large feeding aggregations. One of these happened to contain mostly (and perhaps wholly) younger tadpoles; the other had a mixture of younger and older ones feeding together. As the older animals in the second of these aggregations approached the proper stage of development, they gradually withdrew from the younger feeding tadpoles and tended to form an aggregation of transforming tadpoles nearer the bottom as the younger ones continued their planktonic feeding nearer the surface. Details might have been slightly different, of course, since I was not present when this presumably occurred, but it is almost certainly basically correct, as based upon observations made earlier (Bragg, 1959) when I saw two similar feeding aggregations of tadpoles, all of the same age, change from feeding aggregations to metamorphic aggregations.

This idea was substantiated in a measure during the next two days. About 8:30 a.m., the day after I had seen these aggregations in the afternoon, many young, fully transformed juveniles were on shore, some at least 30 feet from the pool's edge and a single large aggregation was in the pool. In another day, no spadefoot tadpoles remained in the water, and the number of juveniles about the pool had increased. Two days later I could find none. Apparently, therefore, the above-described subgroup had emerged from the pool the night after I had seen them, and the others during the next night. They had taken 35 days to complete the aquatic phase of development (April 13 to May 19 and 20). This indicates a developmental rate close to the average found during other years (Bragg,

1959). It is noted that no demonstrable difference among individual developmental rates occurred.

At the emergence of the spadefoots, the toad tadpoles were growing well but showed no signs of metamorphosis. They transformed exactly 20 days later than the spadefoots (June 8 and 9), or 55 days from the egg stage. They also emerged in two groups, one a day behind the other, indicating that they too, were in two age groups with all individuals maintaining about the same developmental rates. At the time of the toad metamorphosis, the frog tadpoles gave no evidence of impending metamorphosis. I followed them no further. However, tiny frogs were abundant in late June.

Thus it is shown that these three species differ intrinsically in developmental rates, since all tadpoles were subjected to exactly the same environmental conditions. The spadefoots are much the fastest; the toads intermediate; and the frogs slowest in developmental rates.

I wish to express my thanks to Dr. Harriet Harvey for a critical appraisal of this manuscript.

Literature Cited

Bragg, Arthur N. 1944. Observations on the ecology and natural history of Anura XIII. Breeding habits, eggs, and tadpoles of *Scaphiopus hurterii*. Copeia 1944(4):230-240.

———. 1950. Some adaptations of survival value in spadefoot toads. Researches on the Amphibia of Oklahoma. Univ. of Oklahoma Press, Norman. Art. 7:101-116.

———. 1950a. Breeding and tadpole behavior in *Scaphiopus hurterii* near Norman, Oklahoma, spring 1949. The Wasmann Collector 6:69-78.

———. 1950b. Observations in *Scaphiopus*, 1949. The Wasmann Jour. Biol. 8:221-225.

———. 1954. Aggregational behavior and feeding reactions in tadpoles of the Savannah spadefoot. Herpetologica 10:97-102.

———. 1959. Behavior of tadpoles of Hurter's spadefoot during an exceptionally rainy season. The Wasmann Jour. Biol. 17:23-42.

——— and O. M. King. 1961. Aggregational and associated behavior in tadpoles of the plains spadefoot. Wasmann Jour. Biol. 18:273-289.

King, Otis M. 1960. Observations on Oklahoma toads. Southwestern Nat. 5:103.

Richmond, Neil D. 1947. Life history of *Scaphiopus holbrooki holbrooki* (Harlan). Part I. Larval development and behavior. Ecology 28:53-67.

Trowbridge, A. H. and M. S. Trowbridge. 1937. Notes on the cleavage rate of *Scaphiopus bombifrons* Cope with additional remarks on certain aspects of its life history. Amer. Nat. 71:460-480.

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Noteworthy Records of Amphibians from Mexico

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The amphibian fauna of parts of Mexico is so little known that it is deemed worthwhile to place on published record certain specimens secured by two of us (Chrapliwy and Williams) in the summer of 1958. About 1400 amphibians are among the 2200 specimens obtained. The collection is primarily from the dunes areas of southeastern Chihuahua, southwestern Coahuila and northeastern Durango; however, specimens were also taken in Aguascalientes, northern Jalisco and Zacatecas. Certain cognate noteworthy specimens in the Museum of Natural History, University of Illinois, are also reported for the first time.

Species and subspecies for the first time recorded from certain states are as follows: Aguascalientes, *Bufo cognatus, Bufo punctatus, Pternohyla dentata*; Durango, *Scaphiopus couchi;* Guerrero, *Hyla eximia*; Jalisco, *Bufo punctatus*; San Luis Potosí, *Gastrophryne olivacea olivacea.*

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All specimens unless otherwise indicated are in the University of Illinois Museum of Natural History (UIMNH) to which catalogue numbers refer.

Spea bombifrons (Cope).—The plains spadefoot toad was first reported in Mexico by Firschein (1950:75) from four localities in Chihuahua. No further records for Mexico have appeared subsequent to that report. Specimens at hand from various localities in Chihuahua indicate that the species is more widely distributed in northern Mexico than the previous report suggests. We secured specimens from the following localities in Chihuahua: 12.9 mi. SW Aldama (45908), 9.0-9.1 mi. NW San Buenaventura (45099-45101), 20.4 mi. N Moctezuma (45071-97), and 4.7-10.4 mi. SE Galeana (45102-3). The latter locality is the westernmost one for *S. bombifrons* in Mexico. At the Moctezuma locality *bombifrons* was found at night in a pool formed by recent rains; associated and also in chorus were *Bufo debilis insidior, Bufo cognatus,* and *Spea h. hammondi.* The *B. d. insidior* called from short clumps of grass near the water's edge. All specimens of *bombifrons* possess a prominent bony boss between the eyes.

Scaphiopus couchi Baird.—Couch's spadefoot toad occurs widely over the Mexican plateau and adjacent coastal areas, but it has not

been reported from Durango. A large series of specimens was secured at 5.4-5.9 mi. NE Cd. Durango (44984-45019, 45026), 19.1 mi. NE Cd. Durango (45020-25), and at 18.9-25.3 mi. S Tlahualilo (44265, 44977-83), all in Durango. Most of the individuals were taken from roadside pools, in chorus, following an afternoon rain; several were found on the road at night. Other anurans found in association with the spadefoots near Cd. Durango, and also in chorus, were *Bufo debilis insidior* and *Spea h. multiplicata*. An adult female (31842) from near Pasaje in the collections of the Museum of Natural History, provides an additional record for Durango.

Bufo cognatus Say.—Specimens were taken in chorus at night from roadside ditches or found on the road at night following recent rains. *Aguascalientes*: 18.5 mi. S Rincón de Romos (44009-12). 9.4-22.3 mi. E Aguascalientes (44018-30), and 3.0-31.5 mi. SW Loreto, San Luis Potosí, *in* Aguascalientes (44013-17). *Coahuila*: 1.6-4.0 mi. E San Pedro (44042, 43948-58), 11.4 mi. W San Pedro (44043), 5.0-6.4 mi. SE San Pedro (44040-41), and 0.6 mi. E Matamoros. This toad has not been previously recorded from Aguascalientes.

Bufo debilis insidior Girard.—This subspecies has been recorded in Durango only from 5 mi. N Conejos (Sanders and Smith, 1951: 145). A series was secured at 22.6 mi. SE Cd. Durango (44448-9), 4.7-19.1 mi. NE Cd. Durango (44266-44447, 44630-34, 44638), 7.3 mi. NW Bermejillo (44260-64), and 2.4 mi. SE Zavalza (44636-7), all in Durango. In Chihuahua specimens were taken at 1.8-4.1 mi. SE Escalón (44451-64), 6.9 mi. NE Escalón (44465-44624, 44627-29), 4.4 mi. NE Jiménez (44625), 3.9 mi. S Camargo (44259), 1.5 mi. N Saucillo (44626), and 20.4 mi. N Moctezuma (44256-58). Most of the toads were found calling at night on the edge of roadside pools formed by late afternoon or early evening rains. Some individuals were found on the road at night following rains. All of the above localities are on the western edge of the range and fill in the gaps in distribution plotted by Sanders and Smith (*op. cit.*:148, fig. 1) and Savage (1954, Texas Jour. Sci., 6:110, fig. 3).

Bufo punctatus Baird and Girard.—One specimen (43916) found on the road in the evening following an afternoon rain, 16.7 mi. W Sombrerete, represents the third recorded station of occurrence in Zacatecas. The species was reported previously from Concepción del Oro Mts. and 3 mi. SW Jalapa in Zacatecas. Four specimens (43914-5, 43918-9) from 23 mi. E Aguascalientes, Aguascalientes, *in* Jalisco, are the first to be recorded from Jalisco. Two individuals (43920-21) from 6.9 mi. NE Escalón, Chihuahua, taken in amplexus from a stock pond at night, differ from all of the above in lacking marks on the belly and chest. Other amphibians taken at the latter locality and in chorus were *B. debilis insidior* and *Scaphiopus couchi*. Eight adults (43904-907) taken at 2.9 mi. N La Cruz,

Chihuahua, a locality some distance north of the Escalón station, possess scattered spots on the belly and chest and appear typical in all other characteristics. One individual (43917) from 10.7 mi. SW Loreto, San Luis Potosí, *in* Aguascalientes, is the first to be recorded from Aguascalientes. Specimens in the Museum of Natural History provide two additional localities for this species in Zacatecas: a female (25144) is from 2 mi. S Majoma, and two others from La Colorada (25145-6).

Eleutherodactylus augusti fuscofemora Zweifel.—Two adult males (48546-7) and seven juveniles (48548-54) from 5.7 mi. (by road) W Cuatro Ciénegas, Coahuila, are referred to this subspecies on the basis of the black rear surface of the femur, although in the adults the tympanum-length/head-width ratios of 0.166 and 0.168 are nearer the mean for male *E. a. latrans* as plotted by Zweifel (1956, fig. 4). No. 48546 measures 65.4 mm. in total length, tympanum length 5.0 mm. and head width 30.1 mm. No. 48547 measures 71.2 mm. in total length, tympanum length 5.1 mm. and head width 30.2 mm. The rear surface of the femur and the groin are much darker than the ground color of the back and resemble that figured by Zweifel (*loc. cit.*:11, fig. 5C and 25, fig. 11). Webb (1958:263) recently reported a gravid female from near Cuatro Ciénegas, Coahuila, which he referred to *E. a. latrans*. The seven juveniles range in size from 13.0 to 16.5 mm. and were caught at night beneath mesquite. The adults were found at night in separate holes in the ground, their call leading to their capture.

Pternohyla dentata Smith.—This casque-headed hylid has been known only from the type, described by Smith (1957:1). We secured 145 specimens (44764-908) from 9.4 mi. E Aguascalientes, Aguascalientes. All were taken on the night of July 21 from a flooded field with the water level varying from one to four inches in depth. Rain had fallen intermittently in the day and evening. The frogs, in chorus, were not wary and often continued to call after being picked up. Several pairs were observed in amplexus. Other anurans in the flooded field and also in chorus were *Bufo cognatus* and *Bufo c. compactilis*. Two males, one (44909) from 12.9 mi. E Aguascalientes, the other (44910) from 16.4 mi. E Aguascalientes, Aguascalientes, were found on the wet road late at night.

Our specimens possess parasphenoid teeth, a rounded inner metatarsal tubercle, and pointed tips on the digits, thus agreeing with the diagnostic characters of the species given by Smith (*op. cit.*). However, some of the specimens possess a pretympanic ridge (absent in the holotype) such as is found in *P. fodiens*. A sharply defined difference from *P. fodiens* not noted by Smith, but apparent in a large series, is the distance from the ventral margin of the eye to the elevated maxillary flange (directly below the eye), in *dentata* usually less than 1 mm., in *fodiens* from 1 to 2 mm. The

fingers are shorter in *dentata* when compared with individuals of *fodiens* of comparable size and the snout is more flaring and rounded in *dentata* than in *fodiens*.

Features of our specimens are in agreement with the observation of Smith (*op. cit.*) who noted that *dentata* closely resembles *fodiens* in having the same body build, the same general shape of head, limb proportion and the same basic dorsal pattern.

Our series represents the first record from Aguascalientes and provides an extension of known range northwestward about 55 miles from the type locality, Lagos de Moreno, Jalisco.

Hyla arenicolor Cope.—Six males (44758-63) from 26.7 mi. NE El Salto and two males (44756-7) from 30 mi. SW Victoria de Durango (Cd. Durango) provide two additional localities for this hylid in Durango, a state from which there are few records for the species. All eight were found at night in flooded fields in chorus.

Hyla eximia Baird.—This hylid reaches the northern limit of its recorded range in southern Durango. A large series (44709-44) from 2.4-9.7 mi. NE El Salto, Durango, represents a slight extension of known range northeastward from Coyotes (Kellogg, 1932:167). All were taken at night, in chorus, from flooded fields near the road. Four specimens (44750-3) from 7.1-8.4 mi. SW El Salto, four (44745-8) from 2.4 mi. SW Las Adjuntas, and one (44749) from 4.3 mi. NE Las Adjuntas provide additional localities for the species in southern Durango. Two individuals (44754-5) from 18.6 mi. S Rincón de Romos, Aguascalientes, provide the second locality for the hylid in that state. Four specimens (40538-41) in the Museum from 6 mi. NE Tlaxcala represent the second recorded station of occurrence in the state of Tlaxcala. One individual (28299) from Tixtla, Guerrero, appears to be the first record for Guerrero.

Gastrophryne olivacea olivacea (Hallowell).—This subspecies is known currently from few localities in Mexico. Recent records from Tamaulipas (Martin, 1958:55), Chihuahua (Firschein, 1950:75), and Nuevo León (Maldonado-Koerdell, 1949:247) supplement the four localities in Mexico noted by Hecht and Matalas (1946:5). A series from 2 mi. SE Galeana (45428-31), 4.8-7.2 mi. N Saucillo (45396-403), 7 mi. E La Cruz (45404-17), 3 mi. N Camargo (45418-24), and 4.1 mi. SE Escalón (45425-7), all in Chihuahua, provide additional localities for this microhylid in Mexico and suggest a wider distribution in that country than past records indicate. All individuals were taken at night in chorus from roadside ditches or stock ponds; their extreme wariness made capture difficult and time-consuming. Our specimens present a wide range of variation, from a few black spots on the anterior one-third of the tan dorsum to numerous scattered black spots over the entire dorsum continuing posteriorly onto the femur, tibia, and outer edge

of the hind foot. The ventrum is either immaculate or has a few scattered melanophores. Leg-bars (a blotch or spots on the femur and tibia which form a bar or continuous line when the limb is folded), considered diagnostic by Hecht and Matalas (*op. cit.*) in separating *olivacea* from *mazatlanensis* (Sonora, Sinaloa, and southern Arizona) are variously developed. In some specimens (45418-24, 45396-7) the leg-bars are inconspicuous or poorly defined, in others (45400-403) the leg-bars are broad and well developed, similar to the figure of *mazatlanensis* by Hecht and Matalas (*op. cit.*:15, fig. 6).

We take this opportunity to point out that certain apparently unreported specimens are in the Museum: *mazatlanensis*, from 13 mi. NE Los Mochis, Sinaloa (40521); *olivacea*, 26 mi. SW Allende, Coahuila (28117), the third and northernmost locality of record in that State; *olivacea* from "N of Valles, San Luis Potosí" (31325), the first station of record for that State and the southernmost for Mexico; and from 2 mi. E Villa Juárez, Tamaulipas (3624), the third locality for that State.

Rana montezumae Baird.—Two specimens (48544-4) were secured at night from roadside pools at 20.4 mi. E Aguascalientes, Aguascalientes, *in* Jalisco. In both specimens the belly is unicolor, the first finger is longer than the second, the toe tips are slightly enlarged, the subarticular tubercles of the hind foot are relatively small and rounded, and the dorsolateral folds terminate before the groin. In these features our specimens most closely agree with the characteristics for *montezumae* given by Zweifel (1954:139) in his excellent key to *Rana* of Mexico.

Literature Cited

Firschein, I. L. 1950. A new record of *Spea bombifrons* from northern Mexico and remarks on the status of the *hammondi* group of spadefoot anurans. Herpetologica, 6(3):75-77.

Kellogg, R. 1932. Mexican tailless amphibians in the United States National Museum. Bull. U. S. Nat. Mus., 160:1-224, figs. 1-24, 1 pl.

Hecht, M. K., and B. L. Matalas. 1946. A review of middle North American toads of the genus *Microhyla*. Amer. Mus. Novit., (1315):1-21.

Maldonado-Koerdell, M. 1949. Notas Anfibiológicas. III. Sobre algunos anuros del Estado de Nuevo León, Mexico. Revista Soc. Mex. Hist. Nat., 10(1-4):247-250.

Martin, P. S. 1958. A biogeography of reptiles and amphibians in the Gomez Farias region, Tamaulipas, Mexico. Misc. Publ. Mus. Zool., Univ. Michigan, (101):1-102, figs. 1-7, pls. 1-7, maps 1-4.

Sanders, O., and H. M. Smith. 1951. Geographic variation in toads of the *debilis* group of *Bufo*. Field & Laboratory, 19(4):141-160, fig. 1, pls. 1-3.

Smith, H. M. 1957. A new casque-headed frog (*Pternohyla*) from Mexico. Herpetologica, 13(1):1-4.

Webb, R. G. 1958. Frogs of the genus *Eleutherodactylus* from Coahuila, Mexico. Herpetologica, 13(4):263-264.

Zweifel, R. G. 1954. A new frog of the genus *Rana* from western Mexico

with a key to the Mexican species of the genus. Bull. Southern Calif. Acad. Sci., 53(3):131-141, pls. 37-40.

———. 1956. A survey of the frogs of the *augusti* group, genus *Eleutherodactylus*. Amer. Mus. Novit., (1813):1-35, figs. 1-14.

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Colubrid Snakes (*Tantilla, Thamnophis, Tropidodipsas*) from British Honduras and Nearby Areas

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This is the ninth in a series of papers dealing with the herpetology of British Honduras. A new checklist for that country is in preparation; but it is undesirable to offer such now, for each collecting trip to British Honduras has yielded several species previously unknown from the region, and further exploration is intended. The present paper adds one more snake to the list, and discusses the taxonomic status of two others.

Tantilla

A problem relates to the status of the snake named *Homalocranium breve* by Günther (1885-1907:150). Günther's contribution to this publication, the "Biologia Centrali-Americana," was issued piecemeal over a period of years; the fascicle with the description of *H. breve* (No. 19) appeared in 1895. Günther had but one specimen, collected by Osbert Salvin somewhere in British Honduras. Its more significant features were said to be: About 5 inches long excluding the injured tail. Head narrow, depressed; eye diameter about one-third the snout length. Frontal broad, hexagonal. Supralabials 7, the seventh much higher than the sixth. One preocular; 2 postoculars; posterior nasal in contact with preocular; temporals 1+1. First pair of infralabials in contact with each other, separating the mental from the chin shields. Scale rows 15; ventrals 111 (sex not given). Uniform light grayish-olive above, becoming darker on the head; under parts white; no collar or light spots. In the original description Günther did not state which characters he considered especially diagnostic, but in a key to the genus *Homalocranium* he distinguished *H. breve* from *H. canulum* of Yucatán by the condition of the first infralabials, whether in contact or not (*ibid.*: 145).

Cope (1862:74) had previously placed the genus *Homalocranium* in the synonymy of *Tantilla*. Boulenger (1896:226) supplied data on Günther's unique type. Amaral (1929:20) listed the British Honduras species as *T. brevis*. Smith (1940:62) listed it as *T. breve*

and compared its description with *T. lintoni*. The latter was eventually placed in another genus, *Tantillita* (Smith, 1941:115-117). Schmidt (1941:506) included *Tantilla brevis* in his British Honduras checklist. He saw only the type. He noted it to be a female, with 108 ventrals rather than 111 as was given by Günther and also Boulenger. Smith (1942:35), in his résumé of Mexican *Tantilla*, did not mention the extralimital *T. brevis*, but stated that in four Yucatecan *T. canula* the mental might or might not be in contact with the chin shields.

The very low ventral count and general description of *Tantilla brevis* imply that it is close to, if not identical with, *T. canula* Cope (1875:144) from Yucatán. (Cope's paper, usually cited as of 1876, appeared in November, 1875, according to Osborn, 1930:218.) All other *Tantilla*, and *Tantillita*, that might reasonably be expected in British Honduras, have higher ventral counts and other peculiarities (Smith, 1940, 1941, 1942). Stuart (1958:27-28, as *T. breve*), noting Smith's (1942) account of variation in *T. canula*, recommended synonymizing Günther's species with Cope's, at least until additional material became available. Stuart had five specimens, all of them with the infralabial character of *canula*, from Uaxactún in northern El Petén, Guatemala; while from Tikal, a little farther south in El Petén, he had four specimens, three of them *canula*-like but a fourth with the infralabial character of *brevis*. The entire lot of nine snakes was called *T. canula*.

Although regarding Stuart's interpretation as reasonable, we have hesitated to synonymize the British Honduranean *Tantilla brevis* with the Yucatecan *T. canula* because many British Honduras forms are replaced by related but taxonomically differentiated populations in Yucatán (*e. g.*, *Ameiva undulata hartwegi* replaced by *A. u. gaigeae*, *Sceloporus l. lundelli* by *S. l. gaigeae*, *Lampropeltis doliata polyzona* by *L. d. blanchardi*, *Leptophis m. mexicanus* by *L. m. yucatanensis*, *Ninia s. sebae* by *N. s. morleyi*, *Pliocercus elapoides laticollaris* by *P. e. schmidti*, *Stenorrhina f. freminvillei* by *S. f. apiata*, *Micrurus affinis alienus* by *M. a. mayensis*). Also, previous students have not considered a literature report of *T. brevis* from well south of British Honduras; Dunn and Emlen (1932:32) mentioned two individuals from Lancetilla, near Tela, Honduras. One might expect to find little geographic variation in a species that ranged only from Yucatán to northern El Petén and, say, northern British Honduras; but taxonomic homogeneity from Yucatán to Honduras is much less probable, for the two areas are dissimilar ecologically. Finally, on April 10, 1959, at Masson's Mill, about 8.5 miles west and 7.5 miles north of Maskalls, Orange Walk District, British Honduras, we collected a *Tantilla* and noted that its coloration differed from that of Yucatecan *T. canula* but agreed

with the description of *T. brevis*. Obviously the situation merits further study.

Through the courtesy of Ernest E. Williams, of the Museum of Comparative Zoology at Harvard College, we have examined Dunn and Emlen's snakes (MCZ 32196-97), and another example catalogued as from "Honduras: Lean R., Colorado Dist." This is evidently the village of Colorado at the mouth of the Lean River, about 10 miles east of Tela, Atlantida Department, Honduras. Also seen were MCZ 29431-36 from Uaxactún; MCZ 58765 from Tikal; and MCZ 31949 from Chichén Itzá, Yucatán, Mexico. Some additional data were obtained from the aforesaid papers of Boulenger, Cope, Günther, Schmidt, Smith, and Stuart, as well as Schmidt and Andrews (1936:180). It should be noted that Boulenger and Günther were dealing with a single example. Smith's four Yucatecan snakes included Cope's three cotypes and a Chichén Itzá individual, probably the one described by Schmidt and Andrews; Stuart saw some MCZ material from Uaxactún and Tikal.

In Cope's time the name "Yucatán" was often applied to a larger and less precisely defined area than at present. With this reservation, the remarks of Smith (1942, *loc. cit.*) imply that the *brevis* condition of the infralabials may occur, at least occasionally, as far north as Yucatán. However, MCZ 31949 from Chichén Itzá exhibits the *canula* condition as might be expected. Stuart (*loc. cit.*) found the *brevis* condition in only one of nine snakes from the Uaxactún-Tikal area; we find it in MCZ 24931-36 from Uaxactún. All five snakes from Honduras and British Honduras display the *brevis* condition.

Judged from the literature and MCZ 31949, the Yucatecan population is characterized by a relatively light brown dorsal ground color on which darker stippling is evident. Of the seven El Petén individuals seen by us, six are light brown with darker stippling; the exception, MCZ 24936 from Uaxactún, is a medium brown without stippling. The Lancetilla and Masson's Mill snakes are a very dark, uniform brown; the Colorado one, while faded to a medium brown, is uniform; and the type, doubtless faded, was also uniform.

According to previous students of *Tantilla*, and to the key of Smith and Taylor (1945:135), in Yucatecan *T. canula* there is no sharp line of demarcation between the dark dorsal and the light ventral color. We find no line in the Chichén Itzá snake; little or no evidence of such a line in six of the seven El Petén examples; but a very sharp, distinct line in the Masson's Mill and the three Honduras individuals. (The condition in the *brevis* type has not been reported.) The line is zigzag, following the suture between the ventrals and the first scale row.

In Yucatán specimens, described or at hand, there is a mid-

dorsal light streak. On five of the seven El Petén snakes such a streak is present at least posteriorly. The streak is wholly lacking in all British Honduras and Honduras material.

The top of the head is light in Yucatán. In five of the El Petén series there is a light mark on the snout, on the parietals, or on both. The top of the head is completely dark in the British Honduras and Honduras snakes.

The data, while scant, suggest the presence of two fairly well differentiated forms, one of the Yucatán Peninsula and the other of the Central American mainland, the population of northern El Petén (at the base of the peninsula) being essentially of the Yucatecan form but showing some approach to the more southerly one. This is a common pattern of distribution.

Stuart (*loc. cit.*), discussing the occurrence of both the *canula* and the *brevis* infralabial condition in the population of northern El Petén, suggested the possibility of sibling species. However, the two postulated forms are not sympatric species, for there is some intermediacy in that area. MCZ 24936, considered individually, is *brevis* (and is so catalogued), while MCZ 24931 might be called *canula;* but MCZ 24935, with *brevis*-like infralabials, has a fairly light brown dorsal ground color with pronounced stippling, a faint middorsal light streak evidently mostly on the nape and tail, a fairly abrupt transition from the dark dorsal to the light ventral color, a poorly defined light spot on the snout and a bare trace of such on the parietals.

The type locality of *Tantilla canula,* given only as Yucatán, was restricted by Smith and Taylor (1950:352) to Chichén Itzá where the species is definitely known to occur. The type locality of *Homalocranium breve,* given only as British Honduras, may be determined somewhat more precisely; for the British Honduras travels of Salvin, who collected the type, have been described by Godman (1915:3-5, 25). Between 1857 and 1861, Salvin visited this country only at Belize; in 1862 he went down the Belize River from El Petén to Belize, and also cruised about some of the offshore cays to observe the bird life. Cay habitats are *cocotal* and mangrove swamp, neither apt to harbor this snake. Thus Günther's type probably came from somewhere along the Belize River. The banks of the river seem ecologically quite suitable for the species. Other than the Masson's Mill individual, the only specimens for which there are ecological data are those *canula,* or *canula-brevis* intermediates, from Tikal and Uaxactún; these were found under a log or around Maya ruins in forested areas (Stuart, *loc. cit.*). The Masson's Mill snake was beneath a pile of boards on sawdust at a sawmill, in cleared land with relict patches of jungle; we have described the locality elsewhere (Neill and Allen, 1959a:8). Forests, mainly second growth, extend without significant interruption from the banks of the Belize River southward into Honduras; and the

association of the name *brevis* with the more southerly form need not be questioned. The provenience of Günther's type is of some importance, for the populations of extreme northern British Honduras might average closer to the Yucatecan form.

Lioninia vermiformis Hallowell (1861:484), from Nicaragua, was placed by Cope (1862, *loc. cit.*) in *Tantilla*. As noted by Smith (1942, *loc. cit.*), *T. vermiformis* is very similar to *T. canula*. As *vermiformis* is more like the geographically remote Yucatecan *canula* than the geographically adjacent *brevis;* as the three Honduranean *brevis* show no approach to *vermiformis* in ventral count or other characters; and as the teeth of *canula*, but not of *vermiformis*, are somewhat like those of *Tantillita* (Smith, 1941:115-116); it is not postulated that a single species ranges from Yucatán into Nicaragua, although further collecting might demonstrate this.

For the present we list the British Honduras snake as *Tantilla canula brevis* (Günther), 1895; type locality British Honduras, herein restricted by us to the vicinity of the Belize River in that country; known range north-central British Honduras southward into Honduras. Its diagnostic features are summarized as: First infralabials in contact with each other, separating the mental from the chin shields; dorsum of body dark brown; little or no trace of darker stippling; no middorsal light streak; a sharp, zigzag line of demarcation between the dark dorsal and the light ventral color; top of head wholly dark. The infralabial count of 6, the consistent presence of a large anterior temporal separating the supralabial row from the parietal, and the height of the seventh supralabial, may also prove diagnostic when more is learned of variation in the Yucatecan race. The latter becomes *Tantilla canula canula* Cope, 1875; type locality Yucatán, Mexico, restricted by Smith and Taylor (1950) to Chichén Itzá; known range Yucatán southward to northern El Petén Department, Guatemala. Its diagnostic features are: First infralabials usually separate from each other, permitting a contact of the mental with the chin shields; dorsum of body a lighter brown; dark stippling evident on most of the dorsal scales, often forming a reticulum on the head and rows of dots on the body; a middorsal light streak; line of demarcation between dorsal and ventral color indistinct, or if fairly distinct not forming a zigzag along the suture between the ventrals and scale row one; top of head with a light marking involving the snout, the parietals, or both. The infralabials sometimes, perhaps usually, number 7; and the anterior temporal is sometimes, perhaps usually, lost through fusion with the sixth supralabial which thus touches the parietal and becomes the highest of the supralabial series. Intergradation of the two subspecies takes place in northern El Petén.

Thamnophis

Another problem involves certain snakes of the genus *Tham-*

nophis. This problem has been detailed elsewhere (Neill and Allen, 1959b). Thus in the present paper it will be summarized only. A garter snake, variously known as *T. s. sumichrasti* or *T. cyrtopsis sumichrasti,* ranges from southern Mexico southward an undetermined distance into Central America, mostly or entirely at elevations well above 1,000 feet. A few snakes, apparently allied to *sumichrasti,* have also been taken at widely scattered points on the lowlands of the Caribbean drainage. Specimens from Belize, British Honduras, afforded the basis for the description (Bocourt, 1892: 278) of *T. praeocularis;* one from Catmis, Quintana Roo, Mexico, for the description of *T. arabdotus* Andrews (1937:357-358); and those from Granada, Nicaragua, for the description of *T. bovallii* Dunn (1940:191-192). Milstead (1953), in a review of the group, disavowed all lowland records, and reduced to synonymy all names based thereon; but *T. bovallii* was subsequently rediscovered by Shreve and Gans (1958) in Nicaragua and Costa Rica, and *T. praeocularis* by us not far from its old type locality. We felt that these two forms were closely related, but maintained them as separate species chiefly on account of the geographic hiatus between their respective collecting stations; *T. arabdotus* was considered conspecific with *T. praeocularis* although perhaps subspecifically distinct therefrom. The regular fashion in which several characters changed along the Caribbean lowlands, from Quintana Roo to Costa Rica, suggested that there was a lowland species or complex apart from the upland *sumichrasti.* With Nicaraguan and Costa Rican snakes identified as *bovallii,* there arises a question as to how far south *sumichrasti* ranges. Milstead found specimens from no farther south than the uplands of southern Guatemala. There appears to be no garter snake record, of either *sumichrasti* or the lowland group, from Honduras or El Salvador. (There is an old, questionable record for Cartago in the uplands of Costa Rica.)

Charles M. Bogert, of the American Museum of Natural History, brought to our attention, and permitted us to examine, two specimens from Honduras, catalogued as *Thamnophis s. sumichrasti.* AMNH 70209 was taken at Agua Azul Reservation Station, Cortés Department. It displays the following characters: Top of head uniformly black, the dark color extending downward on the supralabial sutures, some of the downward extensions intensified and joined across the upper edges of the supralabials to form a series of inverted U-shaped markings. A bare trace of black lines on the infralabial sutures. A large black occipital blotch fused with dark color of head on each side of the dorsal midline. Dorsal ground color of body dull brown. Middorsal light stripe present only on the neck, and vague there; lateral light stripe on second and third scale rows, present only on the neck and vague there. Two rows of small, irregular black spots between the middorsal and the lateral stripe, the spots more or less staggered but not forming a checker-

board. Another row of dark spots on scale row one, some of them crossing the area of the lateral light stripe to join with spots above this area. Dark spots, of all three rows, posteriorly becoming dot-like and finally indistinct; chin immaculate. A small, dark spot near each end of almost every ventral plate, the spots becoming smaller toward the posterior part of the body and but vaguely indicated on the subcaudals. Dorsal scale rows 19. Ventrals 136; subcaudals 76 (a male). Supralabials 8; infralabials 10; preoculars 2, the upper partially divided; postoculars 3-4. Total length 293, tail length 78 mm.

AMNH 70210 was taken on the shore of Lake Yojoa (where it was eating fish entrails), at El Sauce, Santa Barbara Department, Honduras. Its characters are those of AMNH 70209 except: Mid-dorsal light stripe fairly well defined on the neck, and discernible even posteriorly, three scale rows wide. Lateral light stripe vaguely discernible throughout the length of the body. Dark spots on scale row one mostly reduced to mere dots. Subcaudals 67. Postoculars 3. Total length 321 mm.

Both snakes are of the upland form, and their only unusual character is a tendency toward subdivision of the preocular. However, Milstead found two preoculars to occur, albeit rarely, in other *Thamnophis cyrtopsis sumichrasti*. The range of this form should be extended into the highlands of Honduras. It is of course possible that *sumichrasti*, now considered to range from Guerrero, Mexico, into Honduras, is divisible into two or more subspecies, but material is insufficient to demonstrate this.

The AMNH snakes show no especial approach to our example of *Thamnophis praeocularis*, which has a light head; an elaborate, tricolor head pattern; a well defined black nuchal crossband; very narrow light stripes; rather large, squarish, black dorsal spots forming a tessellation; and a ventral count of 146 (a female). The *praeocularis* has a characteristic head shape, which might be described as somewhat cylindrical, the snout compressed, the outline of the head forming a smooth oval in dorsal view (Neill and Allen, 1959b: fig. 1). A similar head shape was portrayed by Duméril *et al.* (1897: pl. 56, fig. 7) for a cotype of this species, and was described by Andrews (*loc. cit.*) for his *T. arabdotus*. In contrast, *T. cyrtopsis sumichrasti* has a more generalized head shape of the kind found in *T. sirtalis* or *T. c. ocellata*. The AMNH snakes are young and so not especially useful in evaluating the head shape character; at any rate, they exhibit a head shape much like that portrayed by Milstead (*op. cit.*: pl. 1, fig. 1) for a young *T. c. cyrtopsis*, and not like that of our *praeocularis*. It is noteworthy that the latter specimen, although but 39 mm. longer than the larger of the Honduranean juveniles, is a much stouter snake, with the look of an adult. Andrews also commented on the relatively short, stout body of *arabdotus*.

Our previous account mentioned the black peritoneum of *Thamnophis praeocularis*. The remarks may be amplified in the light of recent studies by the senior author on the occurrence and significance of peritoneal melanin deposits in snakes. In *T. cyrtopsis ocellata* and *T. c. sumichrasti* such deposits are heaviest at the posterior end of the peritoneal cavity, and even here they do no more than form a gray wash that fails to obscure the color of the underlying tissue. However, in *praeocularis* at least the posterior third of the cavity is lined with glossy black membrane. A deep black parietal peritoneum is characteristic of many lizards, but has been found in just a few snake species.

Specimens from the uplands of Honduras therefore do not modify the conclusion that *Thamnophis praeocularis* is specifically distinct from *T. cyrtopsis sumichrasti*.

Tropidodipsas

Anthony Wolffsohn, of the British Honduras Forestry Department, called to our attention a snake of the genus *Tropidodipsas*, collected by him at Gallon Jug, Orange Walk District, British Honduras. It was sent to the British Museum (Natural History), where it was catalogued as *T. sartorii*. J. C. Battersby, of that museum, kindly supplied data on the specimen, BM (NH) 1955.1.9.52, as follows: Scale rows 17; ventrals 180; subcaudals 64 (a male). Snout with black patch reaching to posterior edge of parietals; patch followed by a light band. Body with 25 black bands, wider than the light interspaces; some of the latter incomplete ventrally. Tail with 8 black and 9 light bands, the latter all incomplete ventrally. Total length about 560, tail length 117 mm.

Tropidodipsas sartorii has not previously been reported from British Honduras. Subspecific determination cannot be made on the basis of a single specimen. Snakes from El Petén to the west (Stuart, *op. cit.*:25), and one from Quintana Roo to the north (Peters, 1953:231), have been called *T. s. sartorii* Cope; and this designation suffices for the present example, especially since its light bands are interrupted ventrally as is characteristic of this subspecies. However, the black bands are rather numerous on both body and tail.

The Gallon Jug area is forested; we have described it elsewhere (Neill and Allen, 1959a:7).

Literature Cited

Andrews, E. Wyllys. 1937. Notes on snakes from the Yucatan Peninsula. Zool. Ser. Field Mus. Nat. Hist., 20 (25):355-359.

Amaral, Afranio do. 1929. Estudos sobre ophidios Neotropicos. XVIII. Lista remissiva dos ophidios da região Neotropica. Mem. Inst. Butantan, 4(1-8):129-271.

Bocourt, Marie-Firmin. 1892. Le Naturaliste, ser. 2, no. 14:278.

Boulenger, George A. 1896. Catalogue of the snakes in the British Mus-

eum (Natural History). 3. Pp. xiv and 727, 25 pls. 1-25.

COPE, EDWARD D. 1862. Remarks on reptiles. Proc. Acad. Nat. Sci. Phila., 1861:73-75.

———. 1875. On the Batrachia and Reptilia of Costa Rica. Jour. Acad. Nat. Sci. Phila., ser. 2, 8:93-154, 188, pls. 23-28.

DUMERIL, A., M.-F. BOCOURT, AND F. MOCQUARD. 1897. Mission Scientifique au Mexique et dans L'Amerique Centrale, Troisième Partie: Etudes sur les Reptiles et les Batraciens. Pp. xiv and 1012, pls. 1-77.

DUNN, EMMETT R. 1940. Notes on some American lizards and snakes in the Museum of Goteborg. Herpetologica, 1(7):189-194.

——— AND J. T. EMLEN, JR. 1932. Reptiles and amphibians from Honduras. Proc. Acad. Nat. Sci. Phila., 84:21-32.

GODMAN, FREDERICK D. 1915. Biologia Centrali-Americana. Introductory Volume. Pp. viii and 149, 2 pls., 8 maps.

GÜNTHER, A. C. L. G. 1885-1907. *Ibid.* Reptilia and Batrachia. Pp. 1-326, 76 pls.

HALLOWELL, EDWARD. 1861. Report upon the Reptilia of the North Pacific Exploring Expedition, under command of Capt. John Rogers, U. S. N. Proc. Acad. Nat. Sci. Phila., 1860:480-510.

MILSTEAD, WILLIAM W. 1953. Geographic variation in the garter snake, *Thamnophis cyrtopsis*. Texas Jour. Sci., 5(3):348-379.

NEILL, WILFRED T. AND ROSS ALLEN. 1959a. Studies on the amphibians and reptiles of British Honduras. Pubs. Research Div., Ross Allen's Reptile Inst., Inc., 2(1):1-76, 32 figs.

———. 1959b. The rediscovery of *Thamnophis praeocularis* (Bocourt) in British Honduras. Herpetologica, 15(4):223-227, 1 fig.

OSBORN, HENRY F. 1930. Biographical memoir of Edward Drinker Cope: 1840-1897. Nat. Acad. Sci., Biog. Mem., 13(3):124-317.

PETERS, JAMES A. 1953. Snakes and lizards from Quintana Roo. Lloydia, 16(3):227-232.

SCHMIDT, KARL P. 1941. The amphibians and reptiles of British Honduras. Zool. Ser. Field Mus. Nat. Hist., 22(8):473-510.

——— AND E. WYLLYS ANDREWS. 1936. Notes on snakes from Yucatan. *Ibid.*, 20(18):167-187.

SHREVE, BENJAMIN AND CARL GANS. 1958. *Thamnophis bovallii* Dunn rediscovered (Reptilia, Serpentes). Breviora, no. 83:1-8.

SMITH, HOBART M. 1940. Descriptions of new lizards and snakes from Mexico and Guatemala. Proc. Biol. Soc. Wash., 53:55-64.

———. 1941. A new genus of Central American snakes related to *Tantilla*. Jour. Wash. Acad .Sci., 31(3):115-117.

———. 1942. A résumé of Mexican snakes of the genus *Tantilla*. Zoologica, 27(7):33-42.

——— AND EDWARD H. TAYLOR. 1945. An annotated checklist and key to the snakes of Mexico. U. S. Nat. Mus., Bull. 187:i-iv, 1-239.

———. 1950. Type localities of Mexican reptiles and amphibians. Univ. Kansas Sci. Bull., 33, pt. 2(8):313-380.

STUART, L. C. 1958. A study of the herpetofauna of the Uaxactun-Tikal area of northern El Peten, Guatemala. Contr. Lab. Vert. Biol., no. 75:1-30, 1 table.

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The Food of Some Lizards from Fort Benning, Georgia

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Few studies have been made of the food of lizards occurring in our southeastern states. Most are of a fragmentary nature, and usually included in taxonomic studies, annotated lists, or books dealing with lizards.

The Fort Benning Military Reservation is located in Chattahoochee and Muscogee counties, Georgia. Details of the collecting area have been described elsewhere (Hamilton and Pollack, 1956).

In the present study, the percentage and volume of the food is recorded. The larger *Eumeces* and *Ophisaurus* occasionally feed on smaller lizards; they may take invertebrates at approximately the same time. Thus it may be problematical, where both occur in the stomach, whether the invertebrate is of secondary origin, i.e., from the stomach of the vertebrate prey. We may discount the presence of secondary food in most of the specimens examined, since other lizards which had been eaten were usually little digested and their viscera unexposed. Often the size of the invertebrate food precluded the possibility of the ingested vertebrate having eaten it.

Pollack made the collections and field notes from September 1949 to May 1952. Hamilton examined the preserved specimens for food, reproduction, and made the determinations. The food of *Eumeces egregius* has been reported upon elsewhere (Hamilton and Pollack, 1958). The arrangement and nomenclature of Schmidt (1953) is followed in this report.

Anolis carolinensis carolinensis.—This is not a common species at Fort Benning. Six stomachs, contained Diptera, Coleoptera, wasps, and caterpillars. Two had eaten part of their cast skin.

Cnemidophorus sexlineatus.—This abundant lizard has been the subject of several food studies. Burt (1928) reported on 15 lizards, indicating as food grasshoppers, moths, caterpillars, spiders, snails, beetles, bugs, hymenopterans, and flies in that order. Force (1925) listed, in order of importance, Locustidae, arachnids, Myrmicidae and Formicidae, insect larvae, Elateridae, mayfly nymphs, and mosquito larvae as food of 18 Oklahoma lizards. Fitch (1958) states that these lizards, as compared with some others, are dainty feeders, which spend a long time killing, and worrying their prey, and sometimes reducing it to small morsels, instead of gulping down relatively large objects. The often large and relatively intact prey in lizards we examined did not substantiate the observations of Fitch.

From a large collection of these lizards made from February

through November, 1949 to 1951, 100 were selected for food analyses. Snout-vent length varied from 34 to 76 mm. All food items are considered of primary origin. Ten lizards contained a single food item, as a grasshopper or spider. One lizard had eaten a large orthopteran, *Scudderia,* equal to a fourth of its weight. Another distended stomach contained two adult beetles and two coleopterous larvae, one hemiteran, one membracid, one spider, one cutworm, and a small snail. A fully distended stomach of a large *Cnemidophorus* will accommodate 5 cc. of food.

Insects are the dominant food, occurring in 80 per cent of all stomachs. Orthopterans are the primary insect food. These include *Shistocerca, Scudderia,* gryllids, and small cockroaches. Caterpillars, usually hairless species, are taken in quantity. Beetles include carabids and their larvae, Scarabaeidae, Silphidae, Tenebrionidae, and Chrysomelidae. Hemiptera include the families Reduviidae, Coreidae, and Miridae. Homoptera are represented by the Membracidae and Cicadellidae. Several dipterans had been consumed. In spite of their great abundance, few ants were taken, occurring in only three stomachs. Termites, earwigs, and a single small odonatid had been eaten. Large and small spiders of several genera were consumed. These include *Lycosa, Pardosa, Synema,* and *Tennesseellum.* The ingested gastropod molluscs were *Triodopsis* and *Vertigo,* Table 1.

TABLE 1.—Food of 100 *Cnemidophorus sexlineatus.*

Food	Per cent of Occurrence	Per cent of Volume
Insects	80	75.2
Orthoptera	61	39.6
Caterpillars	29	15.8
Coleoptera	27	8.1
Hemiptera	12	2.9
Homoptera	3	.7
Diptera	3	.4
Hymenoptera	4	1.7
Dermoptera	2	.8
Odonata	1	.8
Undetermined insects	7	3.9
Spiders	41	21.2
Molluscs	9	3.5

Eumeces fasciatus.—While this skink is a common species at Fort Benning, the larger number were taken from hibernating sites in punky logs and did not contain food. The 12 specimens that had eaten contained the following. Four stomachs contained orthopterans, chiefly blattids; three contained spiders; two con-

tained snails; and one each contained a lizard, caterpillar, beetle, centipede, and wasp.

Eumeces inexpectatus.—Thirty one lizards were examined, of which 24 (77.4 per cent) contained food. These individuals had body lengths of 54 to 79 mm., the mean being 63.3 mm. Beetles and orthopterans were the most frequent insect food. A *Lygosoma* had been eaten by one lizard, while remains of their own shedding skin were recovered from two stomachs, Table 2.

TABLE 2.—Food of 24 *Eumeces inexpectatus.*

Food	Per cent of Occurrence	Per cent of Volume
Orthoptera	29.2	28.2
Coleoptera	29.2	23.7
Spiders	25.0	13.8
Undetermined insects	12.5	11.5
Lizard cast skin	8.3	7.5
Lepidoptera	4.2	4.2
Lizard	4.2	4.2
Centipede	4.2	3.2
Hemiptera	4.2	2.3
Mollusca	4.2	1.7

Eumeces laticeps.—Eleven specimens of this lizard contained food. These individuals had body lengths of 72 to 120 mm., the mean being 92 mm. Four contained lizard remains, one large individual having eaten three other lizards. The prey species, with the exception of a single *Lygosoma*, appear to be *Eumeces*. Orthopterans and spiders were found in three stomachs each, while single stomachs contained a caterpillar and a snail. The remaining stomachs contained beetle fragments.

Lygosoma laterale.—This is the most abundant lizard at Fort Benning. It is more secretive than most other lizards of the area, usually remaining under cover. Specimens were secured by raking away leaves and debris in the wooded areas. The food has been recorded by Lewis (1951) who examined 25 adults and 25 juveniles in the Houston, Texas, area. Ants, wasps, flies, beetles, Homoptera, Collembola, Thysanoptera, Orthoptera, chilopods, spiders, amphipods, gastropods, and earthworms had been eaten. Lewis noted that captive individuals did not eat snails or centipedes. While isopods were torn apart, they were seldom eaten.

One hundred fifty-four stomachs were examined, of which 12 were empty. The contents are recorded in Table 3. These lizards were collected from February to November inclusive. Snout-vent length of 106 adults ranged from 35 to 51 mm. with a mean of

40 mm. The snout-vent length of 48 juveniles ranged from 23 to 33 mm. with a mean of 28.4 mm.

TABLE 3.—Food of 142 *Lygosoma laterale*.

Food	Per cent frequency of occurrence	Per cent of Volume
Insects	83.1	75.1
Coleoptera	26.8	15.0
Hemiptera	22.5	12.4
Caterpillars	16.9	10.9
Hymenoptera	14.1	8.2
Orthoptera	12.0	10.6
Isoptera	8.5	7.3
Diptera	7.7	3.3
Lepidoptera	5.6	3.6
Mecoptera	1.4	.7
Collembola	1.4	.4
Neuroptera	.7	.6
Siphonoptera	.7	Trace
Undetermined insects	2.8	2.1
Spiders	22.5	14.2
Millipedes	9.9	4.9
Centipedes	2.8	2.4
Isopods	2.8	1.9
Mites	2.8	.2
Molluscs	1.4	.5
Lizard skin	1.4	.9

Stomachs usually contained several different prey items. One lizard had a greatly distended stomach containing 23 termites. Small beetles appear to be the most important food of these lizards. Of these, the chrysomelid *Phyllotreta vittata*, the erotylid *Tritoma mimetica* and the cucujid *Cathartus advena* were recovered from three or more stomachs. Ants, the most abundant food item in the size range eaten by *Lygosoma*, were recovered from only 20 (14 per cent) lizards.

When attacking a meal worm, the lizard grasps the insect in any part of the body, shakes it vigorously and then releases it. Often a mealworm is grasped in the center of the body and worked through the jaws until the head is reached. Several quick bites are then taken and the insect released momentarily. Again the process is resumed, the vigorous shaking in time resulting in a broken and softened prey. About six minutes is consumed in engulfing a large mealworm. The jaws work in a measure like those of a snake when engulfing food. The skin is shed in small pieces, the lizard biting these off and eating them.

TABLE 4.—Food of 149 *Ophisaurus ventralis.*

Food	Per cent frequency of occurrence		Per cent of Volume	
Insects		77.2		72.9
Caterpillars	52.3		45.2	
Orthoptera	20.0		12.7	
Coleoptera	17.4		11.1	
Isoptera	.7		.7	
Neuroptera	.7		.7	
Undetermined insects	2.7		2.2	
Crustacea		24.2		16.6
Isopoda (sowbugs)	20.0		14.1	
Crayfish	4.0		2.4	
Reptiles		8.8		5.9
Lizards	5.4		3.5	
Snakes	3.4		2.4	
Spiders		3.4		1.2
Millipedes		2.0		1.1
Molluscs		2.0		1.1
Earthworms		2.0		1.0
Centipedes		.7		.1
Mammals		.7		Trace

Ophisaurus ventralis.—The range of both *Ophisaurus ventralis* and *O. attenuatus* falls within the Fort Benning area. A critical examination of glass lizards collected in this area reveals all to be *O. ventralis.* The food of *Ophisaurus* has not been thoroughly investigated. Cope (1900) states that it is a rapacious feeder, living principally on arthopods. From the stomach of a Florida specimen, Cope recovered three spiders, a grasshopper, a cricket, a cockroach, a coleopterous and a lepidopterous larva, and a small snail. Hartman (1906) recovered grasshoppers, a cricket and a large caterpillar from a Kansas individual. The food of Florida glass lizards consists chiefly of insects, small snakes and lizards, while captive individuals may be cannibalistic (Carr, 1940). According to Ditmars (1936), earthworms, slugs, insect larvae, and the eggs of ground nesting birds are eaten.

Of 162 specimens examined, 149 (92 per cent) contained food. Ninety-two individuals were taken at Fort Benning and 70 were collected in suburban gardens at Phenix City, Alabama, five miles distant from Benning. July and August specimens account for 73 per cent of those examined.

Specimens examined for food varied in snout-vent length from 64 mm. to 253 mm. The mean of 119 specimens over 110 mm. was 155.6 mm., with 80 per cent between 120-190 mm. Thirty-nine

specimens under 110 mm. had a mean of 93.7 mm., 80 per cent of which ranged between 81-109 mm. Clyde Brown of Phenix City assisted in the capture of these lizards. He placed small mats of hay and lawn clippings about his yard and periodically inspected these. Such retreats proved productive and many lizards were recovered beneath them. In addition to the *Ophisaurus*, a number of *Storeria dekayi* were taken from these situations. Brown searched for glass lizards at night, and while he frequently saw them foraging, they usually evaded capture. On April 10, 1950, Brown plowed a small garden at Phenix City and recovered 12 *Ophisaurus*. In 1949, 30 glass lizards were taken and in 1948, the plowing revealed 119 lizards on the same plot. On February 2, 1950, temperature at 75° F., a mound formed by dumping rich soil was opened at Fort Benning. It measured 8 feet by 2 feet by 18 inches high, and was honeycombed with the tunnels of *Ophisaurus*. Six adults were recovered from this mound, five of which contained food. Plowing in March and April uncovered these lizards at depths of two to ten inches. They appear to favor rich, moist soil, where burrowing is easier and a more varied food supply is available.

In most instances, a single food organism was recovered from a glass lizard. When snakes or lizards were found together with invertebrate food in the stomachs it was usually considered that both were primary food organisms. This is believed to be so since the insects and other invertebrate remains were presumably either too large to have been ingested by the small lizards or snakes found together in the stomachs, or the reptilian prey and arthropods showed little digestion and were separated from one another in the gut. The food is summarized in Table 4.

Caterpillars of many species were eaten. Cutworms were most frequently consumed, as many as eight individuals being found in a stomach. The Orthoptera included *Scudderia furcata* and *Schistocerca damnifica, Gryllotalpa, Gryllus,* and small blattids. Beetles are represented by Carabidae, Scarabaeidae, Tenebrionidae, and Elateridae. One *Ophisaurus* contained more than 40 termites, while another had eaten a lace-winged fly, *Chrysopa*. Crustacea are represented primarily by isopods, which were eaten by a fifth of the lizards. The genus *Oniscus* and *Armadillidium* were eaten. Crayfish remains occurred in four stomachs. Five glass lizards contained remains of their own kind, an obvious instance of cannibalism. One lizard had eaten two eggs that appear to be of its own kind. Other lizards eaten included *Lygosoma* and *Eumeces*. The snakes recovered from five *Ophisaurus* include one *Tantilla coronata* and four *Storeria dekayi wrightorum*. The latter were all small, not exceeding 110 mm. and were presumably recently born young. DeKay's snake frequently shares the same shelter with *Ophisaurus*.

Spiders included lycosids and hahniids. Molluscs, millipedes, and earthworms were represented in three stomachs, while an 85-mm. centipede, *Scolopendra heros*, was recovered from one stomach. A small but distinctly colored patch of hair is presumed to represent *Peromyscus*.

TABLE 5.—Food of 60 *Sceloporus u. undulatus*.

Food	Per cent of Occurrence	Per cent of Volume
Hymenoptera (ants)	73.3	33.6
Lepidopterous larvae	28.3	16.6
Coleoptera	26.7	7.9
Orthoptera	21.7	11.3
Spiders	21.7	10.6
Hemiptera	15.0	4.4
Chilopoda	6.7	3.3
Mollusca	6.7	2.6
Isoptera (termites)	5.0	3.9
Neuroptera (ant lions)	5.0	2.2
Pseudoscorpions	3.3	.3
Mecoptera	1.7	1.7
Millipedes	1.7	1.7
Phalangids	1.7	.6
Shed skin	1.7	.2

Sceloporus undulatus undulatus.—Fence lizards only were collected in warm weather, when feeding conditions for the species were ideal. Of the 69 specimens examined, 60 (87 per cent) contained food. Ants comprised the greater share of the food. In order of their frequency, the following genera were recorded: *Solenopsis*, *Brachymyromex*, *Odontomachus*, and *Dorymyomex*. McCauley (1939) examined 40 stomachs of Maryland *Sceloporus* and recovered ants from 37 individuals. Lepidopterous larvae were often represented by two or three individuals in a single stomach. Beetle families include Carabidae, Scarabidae, Curculionidae, Buprestidae, Staphylinidae, and Coccinellidae. Orthoptera were represented by the families Gryllidae, Blattidae, Tettigoniidae, Acrididae, and a single small phasmid. When a large locust was eaten, it was usually the only food item in the stomach. Spiders were represented primarily by small lycosids. The food is summarized in Table 5.

Thirty-one lizards had body lengths of 53 to 72 mm., while 29 juveniles measured 24 to 36 mm. The food of the two groups was similar, the only difference being reflected in the size of the item eaten. The stomachs are often greatly distended with food. One male with snout-vent length of 55 mm. contained food equal to 11 per cent of its weight, while a juvenile male with snout-vent

length of 28 mm. had stomach contents equal to 12 per cent of its weight. These appear to be the greatest capacity of the stomach.

Literature Cited

Burt, Charles E. 1928. Insect food of Kansas lizards with notes on feeding habits. Jour. Kans. Ent. Soc. 1(3):50-68.

Carr, A. F. 1940. A contribution to the herpetology of Florida. Univ. Fla. Publ. Biol. Ser. 3:1-118.

Cope, E. D. 1900. The crocodilians, lizards and snakes of North America. Rept. U. S. Nat. Mus. for 1898, pp. 155-1294.

Ditmars, Raymond L. 1936. The reptiles of North America. Doubleday, Doran Co., New York. 476 pp.

Fitch, Henry S. 1958. Natural history of the six-lined racerunner (*Cnemidophorus sexlineatus*). Univ. Kans. Publ. Mus. Nat. Hist. 11(2):11-62.

Force, Edith R. 1925. Notes on the reptiles and amphibians of Okmulgee County, Oklahoma. Copeia 141:25-27.

Hamilton, W. J., Jr. and Joseph A. Pollack. 1956. The food of some colubrid snakes from Fort Benning, Georgia. Ecology 37(3):519-526.

———. 1958. Notes on the life history of the red-tailed skink. Herpetologica 14(1):25-28.

Hartman, F. A. 1906. Food habits of Kansas lizards and batrachians. Trans. Kans. Acad. Sci. 20:225-229.

Lewis, Thomas H. 1951. The biology of *Leiolopisma laterale* (Say). Amer. Midl. Nat. 45(1):232-240.

McCauley, Robert H., Jr. 1939. Notes on the food of certain Maryland lizards. Amer. Midl. Nat. 22(1):150-153.

Schmidt, Karl P. 1953. A checklist of North American amphibians and reptiles. Amer. Soc. Ichthyologists and Herpetologists. Univ. Chicago Press. 280 pp.

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On the Occurrence of *Hyla regilla* in the Lower Colorado River, Clark County, Nevada

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The presence of the Pacific tree frog, *Hyla regilla* Baird and Girard, in the lower Colorado River has hitherto been unreported. Bailey and Nelson of the Death Valley Expedition (Stejneger, 1893:224) collected specimens at several localities in Las Vegas Valley, Clark County, Nevada, which were subsequently included in the extensive studies of Test (1898). Stone (1911:224) reported *Chorophilus triseriatus* Wied from Las Vegas Valley, a record which Slevin (1928:120) included under *Pseudacris triseriata*. Linsdale (1940:208) could not verify the record cited by Stone, since the specimens were apparently lost from the collections of the Academy of Natural Sciences at Philadelphia. Van Denburgh and Slevin (1921:30),

Slevin (1928:116), Cowles and Bogert (1936:36), and Linsdale (*loc. cit.*) all listed records of *Hyla regilla* from various localities within and surrounding Las Vegas Valley. The isolated populations of *H. regilla* occurring in certain moist areas (springs) within and surrounding Las Vegas Valley are probably relicts from the last Pluvial period.

Tanner (1931:189) reported *Hyla regilla* from the Narrows of the Virgin River, southwest of St. George, Washington County, Utah. Cowles and Bogert (*loc. cit.*) reported the presence of populations of *H. arenicolor* Cope from the Colorado River basin of southwestern Utah, but provided no records of their occurrence further downstream. Wright and Wright (1949:293) included the Colorado River area of southeastern Nevada within the range of *H. arenicolor*. Stebbins (1951:503) considered southeastern Nevada to be uninhabited by any species of *Hyla*, and later (1954:147) included the Arizona side of the Colorado River within the range of *H. arenicolor*.

Several field trips were made in 1950, 1953, 1954, and 1955, to various localities along the lower Colorado River on the southeastern border of Clark County, Nevada. One of the objects of these trips was to determine the presence of *H. arenicolor* along the lower Colorado River south of Hoover Dam. Although no populations of *H. arenicolor* were discovered, a large concentration of *H. regilla* was found and samples of the population were obtained.

The specimens here reported were collected by nine members of the Stanford Natural History Club in seepage pools on the Clark County, Nevada, side of the Colorado River, opposite the site of historic Fort Mohave (Arizona) on March 21 and 22, 1954, at an elevation of 500 feet. A total of 41 *H. regilla* specimens were collected and bear the amphibian catalogue numbers of the Stanford University Natural History Museum 14081 through 14121. Of these specimens, 25 are males and 16 are females. Of the sixteen females, thirteen contained eggs. The vocal sacs of all the males were well developed.

In measuring the specimens, the standard length was taken to be the distance from the tip of the snout to the end of the coccyx. The standard length of the males ranged from 26.5 to 32.5 mm.; the females from 28.5 to 36.5. The average size of the males was 29.18 mm.; the females 33.56. I am indebted to Mr. Harold E. Munsterman of Menlo College for assistance in making measurements.

Many profound changes in the environment of much of the lower Colorado River basin have taken place with the construction of dams for hydroelectric, metropolitan water supply, and flood control purposes (*e. g.*, Hoover, Davis, Parker, Imperial, and Laguna Dams). The consequent reservoir formation has com-

pletely altered the varied habitats along the river's former flood plain and brought about the extermination of segments of the former indigenous fauna.

Hyla regilla possibly had a much more extensive distribution along the lower Colorado River within very recent time. Mr. Al Jonez of the Nevada Fish and Game Commission told the author that before Davis Dam was completed in 1950, tree frogs were heard along several portions of the Colorado River now inundated by the reservoir Lake Mohave. Since populations of this frog could not be located in the Lake Mohave area within the past few years, it must be assumed that those populations that did exist were exterminated during the process of reservoir formation.

Populations of *Hyla regilla* probably continue to have a limited distribution downstream along the Colorado River in those areas which have not yet been greatly altered by reservoir formation. On March 23, 1954, a chorus of several individuals was heard at Needles, San Bernardino County, California, although no specimens were obtained.

Literature Cited

Cowles, Raymond B. and Charles M. Bogert. 1936. The herpetology of the Boulder Dam region (Nevada, Arizona, Utah). Herpetologica 1:33-42.

Linsdale, Jean M. 1940. Amphibians and reptiles in Nevada. Proc. American Acad. Arts and Sci. 73:197-257.

Slevin, Joseph R. 1928. The amphibians of Western North America. Occ. Papers, California Acad. Sci., no. 17, 152 p.

Stebbins, Robert C. 1951. Amphibians of Western North America. Univ. California Press, Berkeley. ix + 539 p.

———. 1954. Amphibians and reptiles of Western North America. New York: McGraw-Hill Book Co., Inc. xxii + 528 p.

Stejneger, Leonhard. 1893. Annotated list of the reptiles and batrachians collected by the Death Valley Expedition in 1891, with descriptions of new species. North American Fauna, no. 7:159-228.

Stone, Witmer. 1911. On some collections of reptiles and batrachians from the western United States. Proc. Acad. Nat. Sci. Philadelphia, 1911:222-232.

Tanner, Vasco M. 1931. A synoptical study of Utah Amphibia. Proc. Utah Acad. Sciences, 8:159-198, pls. 8-20.

Test, Frederic C. 1898. A contribution to the knowledge of the variations of the tree frog, *Hyla regilla*. Proc. U. S. Nat. Mus., 21:477-492.

Van Denburgh, John and Joseph R. Slevin. 1921. A list of the amphibians and reptiles of Nevada, with notes on the species in the collection of the academy. Proc. California Acad. Sci., 11:27-38.

Wright, Albert H. and Anna A. Wright. 1949. Handbook of frogs and toads. Ithaca, N.Y., Comstock Publ. Co., Inc. xii + 640 p.

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Temperature Responses in Two Tropical Australian Skinks

DANIEL C. WILHOFT

In recent years considerable interest has centered around thermoregulation in reptiles (reviewed by Bogert, 1949a), but little work has been done with reptiles in the tropics. Bogert (1949b) reported eccritic body temperatures in *Sceloporus* at 14° N. latitude. Wilhoft (1958) reported on the preferred body temperatures of two iguanids from the Galapagos Islands (approximately 0° latitude), and Inger (1959) observed the temperature responses of two Bornean skinks (approximately 5° N. latitude). The mean body temperatures recorded here for two skinks, *Leiolopisma fuscum* and *L. rhomboidalis*, appear significantly lower than previous data reported for tropical lizards, with the exception of *Sphenomorphus* from Borneo.

In 1959-60, field work was carried out in northeastern Australia and temperature data were collected over a period of six months. Fifty-nine recordings each of body, air, and substrate temperatures were secured for *L. fuscum* and 18 such records for *L. rhomboidalis*. More data are available for *fuscum* for two reasons. Average snout-vent length of *fuscum* was 70 mm. whereas that of *rhomboidalis* was 47 mm. Body temperatures could be more accurately obtained from the larger skinks. Secondly, *fuscum* could regularly be collected before any escape movements had occurred. Although many more of the smaller skinks were observed during the study period, only 18 temperatures were considered to be accurate. Animals were secured between 9:00 AM and 3:00 PM on clear days either by hand or by shooting with .22 cal. dust shot. Unless the body temperature was obtained before any escape movements had occurred, the temperature was not recorded. Temperatures were taken with a quick-recording Schultheis, 0-50 degrees C. thermometer within seconds after securing the animals. The entire thermometer bulb was inserted into the cloaca.* Lizards were consistently held by a single hind leg to avoid temperature changes caused by handling. Substrate temperatures were recorded with the same thermometer placed in contact with the substrate where the lizard was found. Air temperatures were obtained 18 inches above the ground (bulb shaded).

The *L. fuscum* were collected at sea level in a narrow coastal strip of forest 16 miles north of Cairns (70 miles north of the southern population of *L. rhomboidalis*), latitude 16°44' S, longitude 145°40' E. The strip, exclusive of sandy beach, was approxi-

*Glaser (1959) demonstrated ability to secure accurate body temperature recordings from *Xantusia vigilis* of even smaller snout-vent length using this method.

mately 200 yards wide, the western border being a low coastal range of mountains. Running through this strip was a narrow paved road. Although at least six species of trees were present, the lizards appeared almost completely restricted to the area beneath mangos (*Mangifera indica*) which grew along the road. The large leaves from these trees formed an almost complete blanket over the ground and provided excellent cover for the skinks. Scattered rocks and logs also provided cover. The tree canopy was often continuous and allowed only scattered light to penetrate, forming a mosaic of sunlight and shadow on the ground. *L. fuscum* was often observed basking in these patches of sunlight.

The *L. rhomboidalis* were collected at sea level in and around a tropical rain forest near the town of Innisfail (latitude 17°30' S, longitude 146°0' E). Although closely associated with the rain forest it was invariably found in well-illuminated edge situations around such forests or in areas where the canopy had been disturbed. In areas where logging had been carried out and along trails, it was especially abundant. It was most characteristically associated in these areas with such plants as lantana (*Lantana camara*), native raspberry (*Rubus rosaefolius*), and native ginger (*Alpinia caerulea*), the bases of the latter offering excellent cover for the skinks. Such second-growth vegetation provided a denser undercover, but a mosaic of sunlight and shade was again present. The lizards were typically observed basking on a small fallen branch of lantana or raspberry at the edge of a dense thicket of such vegetation, to which they retreated when frightened.

Climatically both areas can be described as typically monsoon, although the northern one was rather dry for such a climate. Annual rainfall, based on a thirty-year sample, was 86.3 inches for the northern area and 139.1 inches for the southern area, the majority of which falls between January and April. Average ambient temperatures and relative humidity for the areas (also based on a thirty-year sample) are given in Table 1.

Figure 1 records body temperatures obtained during this study. An elevation of body temperature above both the air and substrate temperatures was apparent for all but one of the body temperatures recorded (see legend, figure 1). This is accomplished by basking. Probably one of the best examples of such thermoregulatory basking is that of *Liolaemus multiformis*, an iguanid lizard of the high (max. 16,000 feet) Andes as recorded by Pearson (1954). Pearson suggested three methods by which *Liolaemus* was able to elevate its body temperature above surrounding temperatures. At least two of these methods were utilized by *L. fuscum* and *rhomboidalis* as observed by the writer. In the early morning they were invariably situated up off the substrate on mango leaves, lantana

branches, or small logs. This behavior undoubtedly enabled the lizard to insulate itself from the cooler (if only a few degrees) substrate, which was considerably slower in absorbing solar radiation than the lizard. Secondly, the body was turned "broadside" to the sun. This permitted maximum exposure to solar radiation. Both skinks are predominantly dark brown or black and therefore would be efficient absorbers of solar heat. They were not seen to change color like *Liolaemus;* however, none was observed upon emergence in the morning, so it is not known whether any con-

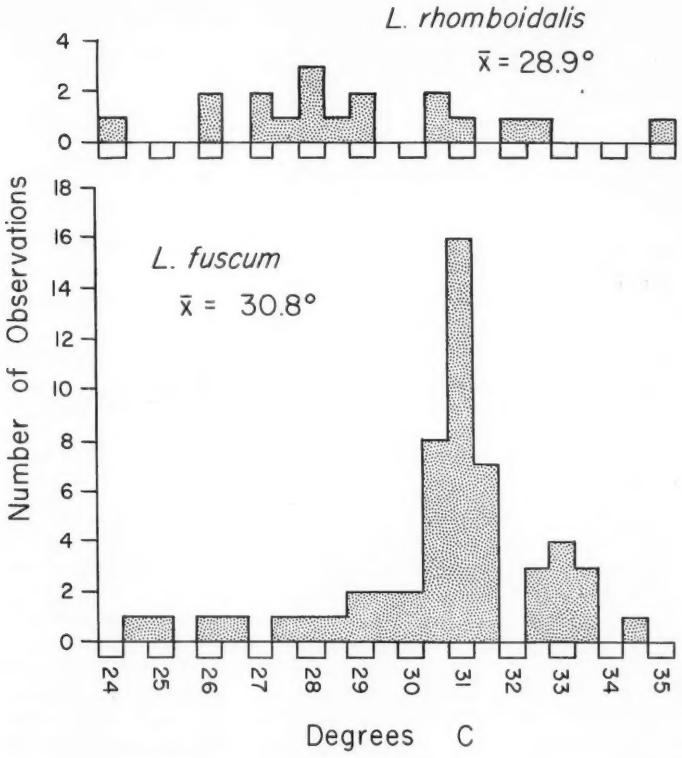

Fig. 1.—Histograms showing body temperatures recorded for two species of *Leiolopisma.* All recordings were obtained from lizards active on surface

	X increase above air temp.	X increase above substrate temp.
fuscum	3.9° ± 0.22°C.	3.4° ± 0.19°C.
rhomboidalis	4.6° ± 0.74°C.	3.8° ± 0.42°C.

TABLE 1.—Ambient temperature (°C.) and relative humidity (per cent) of collecting areas based on standard thirty year period.

		Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Yearly Averages
Average Daily Max. Temperature	Cairns	29.3	30.4	31.6	31.6	31.4	30.4	28.8
	Innisfail	28.2	29.3	30.4	30.4	30.4	29.3	27.7
Average Daily Min. Temperature	Cairns	19.3	21.1	22.2	23.3	22.7	22.3	19.9
	Innisfail	17.7	19.2	21.1	22.2	22.1	21.2	18.2
Mean Temperature for Month	Cairns	24.4	26.1	27.1	27.7	27.0	26.5	24.4
	Innisfail	22.7	24.3	26.1	26.6	26.5	25.5	22.7
Mean Relative Humidity for Month	Cairns	73	75	75	77	78	80	76
	Innisfail	87	84	83	84	85	87	84

traction of the melanophores takes place during the process of warming up. Thus these tropical skinks, although having less of a range of temperature through which to raise their body temperature before reaching the optimum, utilize essentially the same behavioral methods as temperate zone lizards.

The mean body temperature for *L. fuscum* was 30.8°±0.32°C. SE (range 34.5°—24.5°C.), and for *L. rhomboidalis* 28.9°± 0.58°C. SE (range 35.0°—24.2°C.). These means, although based on small samples, would represent the optimum temperature of these lizards as defined by Cowles and Bogert (1944). The lizards had at least three hours of sun and mild ambient temperatures to carry on the process of warming up before body temperatures were secured. Almost all of their body temperatures recorded being higher than ambient temperatures would further suggest they were at their optimum body temperature.

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LITERATURE CITED

BOGERT, C. M. 1949a. Thermoregulation in reptiles, a factor in evolution. Evolution 3(3):195-211.

———. 1949b. Thermoregulation and eccritic body temperatures in Mexican lizards of the genus *Sceloporus*. Anales del Instituto de Biologia 20(1-2): 415-426.

COWLES, R. B. AND C. M. BOGERT. 1944. A preliminary study of the thermal requirements of desert reptiles. Bull. Amer. Mus. Nat. .Hist 83(5):261-6.

GLASER, R. 1959. The "third eye" in locomotor activity and thermal ecology of night lizards, *Xantusia*. Unpubl. Ph.D. thesis, Univ. Calif. library.

INGER, R. F. 1959. Temperature responses and ecological relations of two Bornean lizards. Ecology 40(1):127-136.

PEARSON, O. P. 1954. Habits of the lizard *Liolaemus multiformis multiformis* at high altitudes in southern Peru. Copeia 1954(2):111-6.

WILHOFT, D. C. 1958. Observations on the preferred body temperatures and feeding habits of some selected tropical iguanas. Herpetologica 14(3): 161-4.

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The Critical Thermal Maximum of the Lizard *Sceloporus occidentalis occidentalis* Baird and Girard

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The present investigation treats, in an exploratory way, several aspects of the high temperature tolerance of *Sceloporus occidentalis*, the western fence lizard. The critical thermal maximum (C. T.M.) was determined in individuals from different environments, from the same habitat at different seasons, and in individuals treated in a variety of ways designed to test the effect of specific factors.

Where significant differences occur, they are attributable to (1) natural field acclimation to environmental temperature, (2) thermal acclimation induced in the laboratory or (3) other physiological states (e.g., fasting).

Lowe and Vance (1955) showed that the critical thermal maximum of the lizard *Urosourus ornatus* could be altered experimentally by acclimation to relatively high temperature. In this species the C.T.M. was increased 1.4° C. after acclimation of from 7 to 9 days at a constant temperature of 35° C. and the resistance time at 44° C. was approximately doubled.

In addition, records were made in the field of the body, air, and substratum temperatures for 58 individuals collected under various environmental conditions during several months of the year.

METHODS AND MATERIALS

The apparatus used in the experiments (Fig. 1) consisted of a

metal (24 gauge) container (17×12×10 inches) filled with water and heated with a 1500 watt heating element. The water was circulated with an electrically driven propeller. Temperature of the water was constant to within 0.1° C., in all parts of the tank.

Each experimental animal was placed in a horizontal, wide mouth, quart jar on a platform, of 3/16 hardware cloth one inch from the lower side of the jar, leaving approximately two inches of free space for the lizard above the wire cloth. The jars were 6¼ inches long. Into each jar lid were soldered two pieces of copper tubing, one ¼ inch and the other ⅜ inch inside diameter. These projected approximately ¾ inch into the jar when the lid was in place. A rapid-registering Schultheis 0—50° C. thermometer was placed in one of the copper tubes and a piece of glass tubing (⅜ inch inside diameter) in the other; both were sealed in place with modeling clay. The thermometer bulb was located near the center of the free space above the wire cloth. The glass tube extended approximately 1¼ inches into the jar. Its outer end extended above the water allowing for movement of air. The jars were placed under water and were held by wire racks. When in place, they were side by side, 2 inches apart, with their upper surfaces 1 inch under water.

A piece of folded cheese cloth placed under two 100 watt lamps was used as the site for taking the temperature of each lizard immedately after its removal from its container. The temperature at the surface of the cheese cloth remained at approximately 45°C.

The procedure in determining the C.T.M. was as follows: Lizards were placed on top of the screen in the jars; a folded, water saturated paper towel was placed under the screen. The jars were placed in the water at 30°C. In all experiments the rate of increase in the temperature of the water was approximately the same. At a point in the lizard's activity, characterized by violent twitching of the body, the jars were removed from the water. The water bath part of the experiments lasted an average of 27 minutes. At the conclusion of the water bath each jar was quickly opened and the lizard placed on the cheese cloth under two 100 watt bulbs. The cloacal temperature of each animal was taken within 45 seconds after the jars had been removed from the water bath.

A second method for determining the C.T.M., utilizing sunlight as the heat source, was tested. Lizards were secured to a board by a thread 15 inches long attached to the left hind leg of the animal. This allowed freedom of movement. Initiation of heat induced paralysis was taken as the experimental end-point for the C.T.M., this point being characterized by a violent twitching of the lizard. The sample for the determination of the C.M.T. by the sunlight method is quite small (N=7). The difference between this

small sample and a sample (N=21) for the water bath method, is significant at the 5 per cent level (Table 1). This may or may not indicate a real difference in the C.T.M. depending upon the experimental method used.

The majority of animals were tested by the water bath method. It was found that determination of the end-point was more difficult in the sunlight method. This, plus better control of experimental conditions were the main factors in the choice of the former.

For all samples studied in the present investigation, the standard error of the mean was calculated in each case after using N=1 for calculations of the standard deviation. For all *t* tests, appropriate small sample methods were used (Simpson and Roe, 1939:210-211).

Lizards were collected by noosing, placed in a cloth collecting sack and within four hours were weighed to the nearest 0.1 gram and placed in individual quart jar containers. The lizards were kept in the same laboratory area without food or water for approximately 50 hours at a temperature of from 70 to 85°F.

Samples were obtained from the Great Valley of California near Stockton, San Joaquin County and from Alpine Lake, Marin County, on the coast. Collections were made in the valley on March 28, and between July 21 and August 4 and from the coast on May 26. Each sample is referred to in terms of its origin and season of collection, e.g., Valley-Spring.

The Critical Thermal Maximum

The critical thermal maximum as recognized in this paper is the body temperature at which locomotor activity becomes disorganized and the animal loses its ability to escape from conditions that will promptly lead to its death, yet recovery occurs if the animal is removed to a cool environment (see Cowles and Bogert, 1944 and Lowe and Vance 1955).

The point at which the experimental lizard reached the C.T.M. was usually obvious and was denoted by a violent twitching. Whereas all the lizards were paralyzed at the time of removal from the experimental chamber, 98 per cent recovered locomotor coordination within an hour.

Experimental Results

The levels of significance (*P*) and the values of *t* for all samples compared are summarized in Table 1.

Sexual difference.—There was no statistically significant difference in C.T.M. between the sexes. However, possible sexual differences have been taken into consideration for the remaining kinds of comparisons discussed below. Where there might be ex-

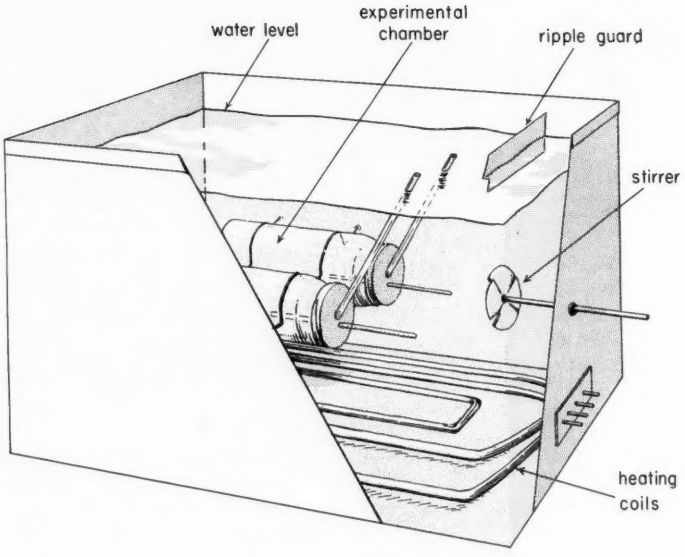

Fig. 1.—Apparatus used to determine the critical maximum temperature of western fence lizards, *Sceloporus occidentalis*.

pected a sex difference in the C.T.M., for example in spring females, the comparisons have been made for males only. Investigation of gravid females in the spring as compared to non-gravid females of this and other seasons and as compared to males, was initiated but not completed.

Seasonal acclimation.—The difference in the C.T.M. between Valley-spring males and Valley-summer males in the same habitat, is significant (P=.01). This probably is an expression of acclimation to environmental temperature as the temperature in the habitat studied increases significantly from April to August (Fig. 2).

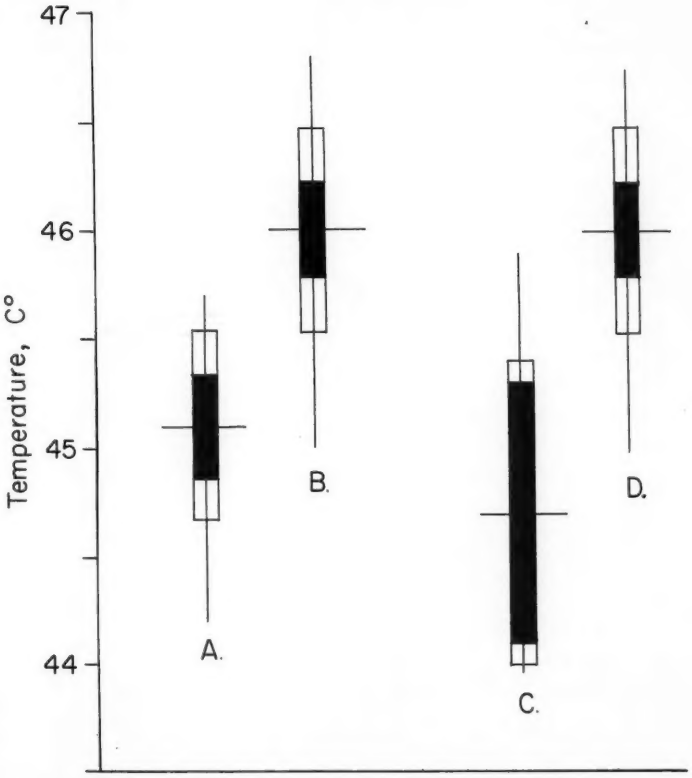

Fig. 2—Comparison of the critical thermal maxima of *Sceloporus occidentalis*, (A) Valley-Spring males, (B) Valley-Summer males. (C) Room controls—25°C. fasting, and (D) Valley-Summer controls—feeding.

climation in this lizard indicates that further ecologic variation may also occur. A comparison of synchronous samples drawn from significantly different habitats such as the cool outer coast and the warm interior valley of California may be expected to demonstrate a significant difference in the C.T.M. However, lizards were not collected on simultaneous days from the two areas. In light of the Valley-spring and Valley-summer comparisons, the similar means of the Coast and Valley-spring might imply habitat acclimation.

Acclimation to low temperature.—Four individuals were placed in a refrigerator at 7°C. for 34 days. The difference in the C.T.M. between this sample after acclimation and the Valley-summer males is significant at the 5 per cent level (Table 1 item No. 4). The mean for this sample (45.4°C.) is lower than for the controls (45.9°C.), as is expected. Larger samples should be tested to check this result, which is consistent with the hypothesis that acclimation to relatively low temperature depresses the C.T.M.

TABLE 1.—Comparisons of the Critical Thermal Maximum of *Sceloporus occidentails* under different conditions.

	No.	Mean	Range	S.E.	Standard Deviation	*t*	*P*
Valley-summer males	13	45.9	45.0-46.4	.20	0.42	.90	.3
Valley-summer females	8	46.1	45.3-46.8	.21	0.60		
Valley-summer males	13	45.9	45.0-46.4	.20	0.42	3.37	.01
Valley-spring males	14	45.1	44.2-45.7	.12	0.44		
Valley-spring	14	45.1	44.2-45.7	.12	0.44	.40	.5
Coast spring	10	45.2	44.4-45.9	.16	0.47		
Cold acclimated (fasting)	4	45.4	44.8-46.1	.34	0.68	2.26	.05
Valley-summer males	13	45.9	45.0-46.4	.20	0.42		
Room controls (25°C., fasting)	6	44.7	44.0-45.9	.30	0.71	5.06	.001
Valley-summer controls (feeding)	21	46.0	45.0-46.8	.11	0.49		
High humidity (100%)	4	45.3	44.5-45.6	.28	0.55	.80	.4
Low humidity (5-10%)	4	45.7	44.8-46.2	.31	0.62		
Tail removal	14	46.0	45.2-46.8	.13	0.49	.29	.7
Valley summer controls	21	46.0	45.0-46.8	.11	0.49		
Water bath method	21	46.0	45.0-46.8	.11	0.49	2.19	.05
Sunlight method	7	45.5	45.0-46.2	.17	0.44		

Under the experimental conditions imposed, (ca. 7°C.) the lizards were not able to feed, but loss of weight was slight due to

the much lowered metabolic rate. The weight lost in this sample, after 34 days at ca. 7°C. averaged 3 per cent. This is considered to be negligible so far as it might influence the C.T.M. Fasting seriously affects body weight at higher environmental and body temperatures; it significantly affected the C.T.M. in experiment No. 5 (Table 1), discussed below.

Fasting.—Fasting at room temperature (30 days at ca. 25°C.) was found to lower significantly the C.T.M. (Fig. 2). The animals in this experiment had lost from 18 to 49 per cent of the initial body weight when tested. The initial and terminal weights and the percentages for weight lost are given in Table 2. The difference between the fed control sample and the fasted sample is highly significant (P of .001, Table 1, item No. 5). This represents the greatest difference found between two samples tested in the present investigation. It is concluded that starved *S. occidentalis* which have lost considerable bodyweight have less resistance to high temperatures than do well fed animals.

Relative humidity.—The effect of air humidity upon the C.T.M. was tested in a single experiment in which 4 animals were used. Whether largers samples would have given significantly different measurements is not known. This is possible, and should be investigated further; however, the test suggests that the C.T.M. is not affected by relative humidities (at the time of heat death) as different as 10 and 99 per cent.

In all experiments except the one referred to as "low humidity", the relative humidity was 100 per cent after the first fifteen minutes of the experiment. Humidity in the experiment referred to as "low humidity" was probably below 10 per cent. Forty grams of Ca CO_3 were used in place of the wet paper towel.

TABLE 2.—Weight loss for a 30-day fast of *Sceloporus occidentalis*.

	Animal Number	Initial Weight (gms.)	Terminal Weight (gms.)	Percentage Body Weight Lost
Cold acclimated 7°C. fasting	262	8.6	8.5	1
"	263	6.5	6.3	3
"	264	11.8	11.2	5
"	267	12.2	11.8	3
25°C. fasting	313	11.2	5.7	49
"	315	10.2	8.4	18
"	310	8.4	6.8	19
"	311	6.3	4.0	37
"	308	11.5	8.1	29
"	309	7.3	5.5	25

Tail removal.—The effect of injury, tested by removing the tail with scissors, produced no change in the C.T.M.

Experimental methods.—The significant difference found (P .05, Table 1, item No. 8) in comparing samples tested by the water-bath versus the sunlight method, has been discussed.

TABLE 3.—Field temperature records (°C.) for *Sceloporus occidentalis.*

	N	Range	Mean	S.E.	Standard Deviation
Body temperature	58	29.9-38.0	34.7	.22	1.69
Males	23	31.0-38.0	34.5	.36	1.74
Females	22	29.9-37.7	33.6	1.56	7.32
Air temperature	47	20.5-40.5	28.4	1.07	7.36
Substratum temperature	48	28.0-52.5	35.4	1.05	7.27

TABLE 4.—Values of t and P for Comparisons of Field Temperature Samples for *Sceloporus occidentalis.*

Samples	N_1+N_2	t	P
Body temperature, males vs. females	45	0.54	$>.5$
Body temperature, (males and females) vs. air temperature	105	6.26	$<.001$
Body temperature (males and females) vs. substratum temperature	106	0.79	$>.4$
Air temperature vs. substratum temperature	95	4.68	$<.001$

FIELD TEMPERATURES: BODY, AIR, AND SUBSTRATUM

Field data pertaining to body (cloacal) temperatures (BT) of *Sceloporus occidentalis,* and associated air (AT) and substratum (ST) temperatures, are given in Table 3. Body temperatures were recorded for 23 males and 22 females. All temperature records were obtained from individuals that were presumably at temperature levels of the normal activity range.

The different value of N for each of the samples obtained in this study is explained by the fact that although a sample of 58 body temperatures was secured, associated substratum and air temperatures were not always recorded. These samples include individuals collected between April and September at various times of day from 9:00 a.m. to 6:00 p.m.

FIELD RESULTS

The results of statistical analysis of the three frequency distributions, BT, AT, and ST, are in Table 3 and 4. Values of t and P, for simple group comparisons, yield significant levels of dif-

ference for each of the comparisons, *viz.*, (1) the body temperature *vs.* the air temperature, (2) the body temperature *vs.* the substratum temperature, and (3) the air temperature *vs.* the substratum temperature. The small difference in means for males and females is not significant ($P=.5$). Accordingly the data for both sexes are combined for the sample representing body temperature ($N=58$) used for comparison with the air and the substratum temperatures.

The mean body temperature falls between the mean air and substratum temperatures and very closely approaches the substratum temperature. The mean air temperature is lower, and the mean substratum temperature is higher, than the mean body temperature. This finding for *Sceloporus occidentalis* agrees with that of Cowles and Bogert (1944).

Summary and Conclusions

Several experiments were conducted to test the level of the Critical Thermal Maximum of the lizard, *Sceloporus occidentalis,* under various conditions. The Critical Thermal Maximum is defined as the temperature at which locomotor activity becomes disorganized and the animal loses its ability to escape from conditions that will promptly lead to its death.

With respect to this temperature it is concluded that:

1.. There is no significant difference between summer-taken males and females.

2. There is a seasonal difference in lizards in their natural environment.

3. Cold acclimation can be induced by refrigeration in the laboratory.

4. Fasting with excessive body weight loss significantly lowers the level of the Critical Thermal Maximum.

5. Differences in humidity appear to have no effect.

6. Tail amputation causes no significant change.

7. An electrically controlled water bath method is superior to the use of the sunlight open air method, in that the criteria for determining the C.T.M. can be more accurately determined and the experimental conditions can be more rigidly controlled.

It is concluded that the mean C.T.M. of this species varies at least .8°C. under natural environmental conditions and can be altered experimentally.

The following conclusions are drawn from field temperature records.

1. There is no sex difference between the means of the normal activity ranges.

2. A significant difference exists between the body temperature and air and substratum temperatures.

3. There is a significant difference between the air and the substratum temperature.

4. There is a closer relationship between body temperature and substratum temperature than to air temperature.

5. The eccritic body temperature varies from approximately 30° to 38° C. (29.9—28.0, mean 34.7±.22).

I would like to thank Dr. Robert C. Stebbins of the Museum of Vertebrate Zoology, University of California, Berkeley, for his welcome advice during these experiments, and to Dr. Charles Lowe, Department of Zoology, University of Arizona, Tucson, for his assistance in the completion of the original master's thesis text.

Literature Cited

Cowles, Raymond B. and Charles M. Bogert. 1944. A preliminary study of the thermal requirements of desert reptiles. Amer. Mus. Nat. Hist. Bull., 83 (5):265-296.

Lowe, Charles H., Jr. and Velma J. Vance. 1955. Acclimation of the Critical Thermal Maximum of the reptile *Urosaurus ornatus*. Science, 122(3158):73-74.

Simpson, G. G. and Anne Roe. 1939. Quantative zoology. McGraw-Hill Book Co., New York, pp. 414.

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Seasonal and Lunar Variation in the Numbers of Mating Toads in Bandung (Java)

Gilbert Church

The reproduction cycles of two tropical amphibians on Java have recently been shown by Church (1960a,b) and his co-workers (1958) to undergo seasonal changes which are related to the varying amounts of rainfall throughout the year. Both species breed at any time of the year but in one, *Bufo melanostictus*, the height of the breeding period in Djakarta coincides with the onset of the northwest monsoon rains in November and December; and in the other, *Rana cancrivora*, the greatest breeding activity takes place during the so-called dry season in August when the paddies in which it breeds are under irrigation.

Concomittant changes in the breeding patterns which follow the lunar cycle have also been demonstated. In the case of *B. melanostictus* more animals were found in the Djakarto area in mating condition during the time of the full moon, but a majority of *R. cancrivora* with large mature ovaries were collected when there was no moon.

Further evidence bearing on the seasonal and lunar changes in the reproductive cycle of *B. melanosticus* from Bandung (Java) is presented here.

Materials and Methods

At the Institute of Technology in Bandung one of the engineering buildings is surrounded by a shallow moat about ten feet wide which is constantly filled with slow-moving, muddy water. Its total length is approximately three hundred feet. In addition to the moat, at one corner of the building there is a shallow pool, twenty by thirty feet, which usually contains about a foot of muddy water. The ubiquitous *B. melanostictus* find this moat and pool ideal breeding places, and both have provided an unending supply of mating adults, eggs and larvae in all stages of development.

The climate of Bandung, except for being cooler because of its elevation of 2400 feet, is similar to that of Djakarta. The monthly rainfall averages and relative humidity are comparable (Schmidt and Ferguson, 1951), and a continuous supply of food is available to amphibians in the area throughout the year.

To continue and extend the Djakarta study of the reproductive cycle of *B. melanostictus*, beginning in January, 1960 and continuing until January, 1961, a daily count (except Sunday) was made every morning between eight and nine o'clock of the pairs of toads in amplexus in the moat and pool. It was expected by this means to obtain more accurate data on the breeding habits of this species than was the case in Djakarta where animals were collected indiscriminately on land or in the water.

Results

In general, the results of this study are in agreement with those of Djakarta on *B. melanostictus*. As in Djakarta, this species was found to breed throughout the year in Bandung with the peak of breeding activity occurring in November and December at the beginning of the northwest monsoon rains when large numbers of mating pairs were in the water almost daily. Mating during the drier period of the northeast monsoon was retarded but an unexplainable secondary peak occurred in June at a time when

Table 1.—Monthly totals of *Bufo melanostictus* in amplexus counted at the Institute of Technology in Bandung from January 19, to December 31, 1960.

Month	No.	Month	No.
Jan. 19-31, 1960	62	July	62
February	145	August	43
March	88	September	65
April	71	October	61
May	74	November	153
June	124	December	182

Total pairs observed = 1130

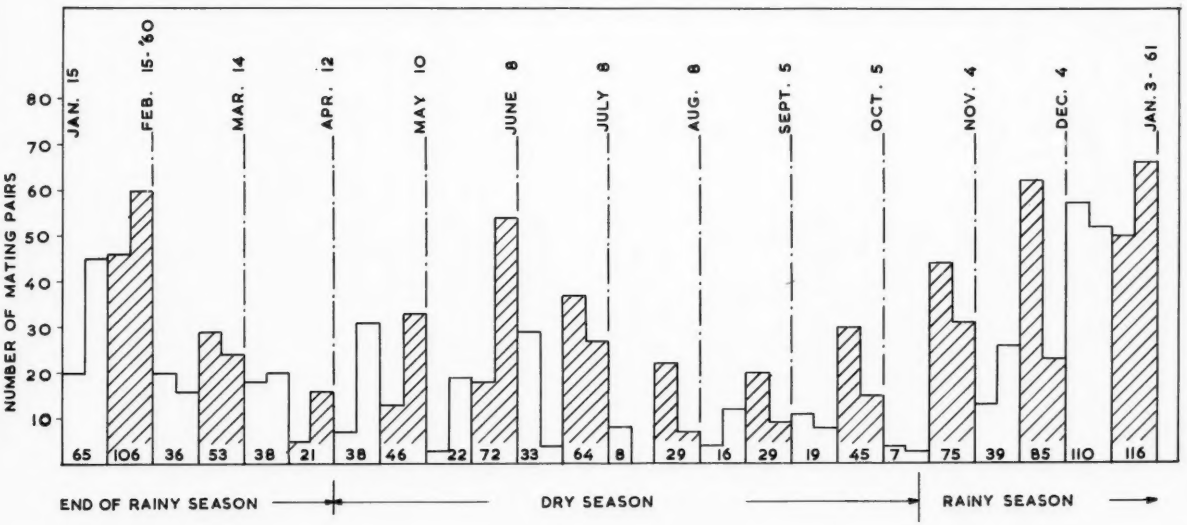

Fig. 1.—Numbers of *Bufo melanostictus* in amplexus counted in different lunar quarters throughout 1960 at the Institute of Technology in Bandung. Shaded areas represent the two quarters of the waxing moon. Vertical lines with dates are days on which the moon was full. Numbers at the base of the graph are totals of animals in amplexus counted during the periods of the waxing and waning moon. The peak of the breeding season occurred in November and December with a secondary peak in June.

the amount of rainfall had considerably lessened. Table 1 lists the monthly totals of mating pairs observed in the moat and pool from January 19 to December 31, 1960.

Although the seasonal variations in rainfall apparently influenced the breeding cycle, the records show no particular correlation of breeding activity with daily rainstorms even during the dry season. To illustrate, in April and May, during a period of eighteen days when no rain was recorded, thirty-two pairs were counted on the fourteenth day of the dry period with smaller numbers recorded on six other days. In August, a month in which the amount of rainfall usually averages less than two inches, two days of rain were recorded, but there were fourteen days in which mating pairs were counted in the moat and pool. Similar observations were made throughout the rest of the year. Such breeding activity, occurring independently of rainfall, contradicts the generally accepted notion that this species usually mates after a heavy rain as numerous other species have been reported to do.

Except for the month of April, more toads were counted in amplexus during the time of the waxing moon when light was increasing than during the period of decreasing light after the full moon. In five of the twelve lunar periods noted, the largest number of mating animals was found in the week before the full moon; in the remaining seven months the largest number occurred during the first lunar quarter (fig. 1).

These data on the effects of the lunar cycle on the mating behavior of *B. melanostictus* are more generalized than those of the Djakarta study, and they show more definite influences of the seasonal cycle. They are also in keeping with observations made on *B. biporcatus* in Bali which indicated a daily increase in the number of females found in water as the moon waxed full (Church, unpublished). But they are in contrast to the observations of Ferguson (1960), who found that *B. fowleri* did not appear on moonlight nights, and Church (1960b), who reported a similar decline in the numbers of *R. cancrivora* during the time of the full moon, although in both cases the decline in numbers applied to animals on land not in the water.

Summary

1. *Bufo melanostictus* breeds throughout the year in Bandung (Java) with the height of the breeding activity coinciding with the beginning of the northwest monsoon in November and December. A secondary peak in breeding was noted during the dry season in June.

2. There was no correlation of breeding activity with daily rainstorms throughout the year studied.

3. With the exception of one month in the twelve studied,

more toads were found in amplexus during the time of the waxing moon than when it was on the wane. In seven months out of the twelve, the largest number of mating pairs was found in the week of the first lunar quarter; in five of the remaining months, the largest number occurred in the week of the second quarter, just before the moon reached fullness.

Literature Cited

Church, G. 1960a. Annual and lunar periodicity in the sexual cycle of the Javanese toad, *Bufo melanostictus* Schneider. Zoologica 45:181-188.

———. 1960b. The effects of seasonal and lunar changes on the breeding pattern of the edible Javanese frog, *Rana cancrivora* Gravenhorst. Treubia 25:215-233.

———, D. T. The, K. T. Sie, J. A. Kusin, K. L. Tio and M. Hussani. 1958. The reproductive cycle of the Javanese toad, *Bufo melanostictus*. Proc. of the First Indonesian Science Congress, Sect. C, Biology, Parts I-V:5-37. Madjelis Ilmu Pengetahuan Indonesia (Indonesian Coucil for Sciences), Djakarta."

Ferguson, D. 1960. Observations on movements and behavior of *Bufo fowleri* in residential areas. Herpetologica 16:112-114.

Schmidt, F. H. and Ferguson, J. H. A. 1952. Rainfall types based on wet and dry period ratios for Indonesia with Western New Guinea. Publication 42:1-72. Kementerian Perhubungan Djawatan Meteorologi dan Geofisik (Meteorological and Geophysical Service), Djakarta."

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The Distribution and Habits of *Sistrurus catenatus* in Northwest Texas

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The distribution of *Sistrurus catenatus* in Texas has not been well defined. Locality records in the literature are few and geographically scattered. With the resurrection of the subspecies *edwardsi* (Gloyd, 1955), recognition of this race and delimitation of the area of intergradation with *tergeminus* pose problems calling for much new material. Little information is available in the literature on the habits of either race.

Strecker (1915) apparently erred in distinguishing *Sistrurus catenatus* from *Crotalus viridis* in northwest Texas. These two species do bear superficial resemblance to one another and occupy similar habitat. Brown (1950) listed all localities from which specimens were available, but could verify no records for northwest Texas. A more recent work by Fouquette and Lindsay (1955) dealing with northwest Texas does not list this snake. Their study, though extensive, apparently did not include night driving of

highways, the most effective means for obtaining this species.

The new locality records given in this paper, extending the known range in Texas 200 miles west and northwest, indicate a much wider distribution for this snake than formerly thought and also indicate that *Sistrurus c. edwardsi* may occur in northwest Texas.

Distribution and Habits.—Sistrurus catenatus probably occurs over most of central and west Texas with the possible exclusion of the Edwards Plateau region and the far southwest, since extensive fieldwork in the two last-named areas has failed to reveal its presence (Fig. 1).

With the exception of one individual obtained in Throckmorton County under a clump of bear grass, all specimens listed were found alive or dead on the highways. This snake emerges in the evening and remains on the roadway for a short period of time. They usually appear coiled on the road at dusk and possibly remain in this position for several hours if not killed by vehicles. Their occasional abundance on the road is greatly influenced by season and prevailing weather conditions.

All specimens obtained in Roberts and Lipscomb Counties, in the northeastern part of the Panhandle, were taken during the middle of August, 1960. They first appear on the road shortly before dusk (8 p.m.) but may be found there for several hours if higher road substrate temperatures than surrounding air prevail.

In Throckmorton and Shackleford Counties on the low plains, though snakes were collected at approximately the same time of day as above, they were most abundant during May and early June. On May 14, 1960, fifteen *Sistrurus catenatus* were collected between Throckmorton and Woodson in Throckmorton County, a distance of sixteen miles. Several other specimens were collected on this road in early June of the same year. Extensive night driving of this highway yielded nothing during July and August. The difference in seasonal abundance could be due to climate, since the Panhandle areas have a much later spring and greater daily temperature fluctuations.

The diversity and abundance of various species of snakes on highways in west Texas is greatest in late spring. Whether this can be attributed to chance or actual preference for road substrate is open to question. Present evidence tends to favor chance occurrence. These snakes are probably motivated to seek a mate, obtain food, or are attracted to the heat held by the roads after decrease in air temperature. They may remain on the road for the heat afforded to them and be distracted from their primary objective.

Night driving in late spring and early summer should produce a considerable number of new locality records where this snake

was considered rare or nonexistent. Driving should commence just prior to dusk and continue until at least 10 p.m.

Ecological Setting.—*Sistrurus catenatus* occurs in a variety of habitats. It is found in the Rio Grande Valley, the low plains consisting of mesquite, juniper and overglazed grassland, in the sandhill region of west Texas, as well as in the high rolling plains of the Panhandle.

Extending from Palo Duro Canyon near Amarillo southward to Midland and Odessa is an area of intensely eroded terrain. This is accentuated by resistant limestone outcropping which results in an elevation difference of three to four hundred feet. This break between high and low plains comprises the Caprock which follows a somewhat erratic course in west Texas, and serves as a distinct barrier to many eastern forms, although some of these have succeeded in penetrating this barrier along several water courses. *Sistrurus catenatus* appears to be one such form, invading the Canadian River Valley and possibly several other regional systems.

Sufficient specimens have been examined taxonomically to show that differences exist between those individuals collected above the Caprock and those obtained below on the low plains. The high plain representatives approach the subspecies *edwardsi* more closely than *tergeminus*. It is possible, but cannot yet be shown, that intergradation occurs along the Caprock.

Variation in Specimens from Northwest Texas.—Gloyd (1955) differentiated the subspecies *edwardsi* from *tergeminus* by the number of scale rows at midbody and by color differences. The average number of scale rows at midbody in *edwardsi* was 23, in average number o fscale rows at midbody in *edwardsi* was 23, in *tergeminus* 25. Color differences are present, but not necessarily pronounced, with *edwardsi* having a somewhat lighter dorsum and more nearly immaculate ventrum than *tergeminus*.

It does not appear that the characters listed above are suitable to designate subspecies in the specimens thus far examined and included in this paper. There is marked variation in dorsal scale counts, even in individuals from the same area. This is true for many of the other characteristics also examined. A summary of diagnostic characteristics examined is shown in Table 1.

That specimens from the low plains show differences not present in high plain representatives is evident. The number of specimens available for study from northwest Texas is limited, so designation of subspecies awaits further collecting.

Those specimens from Andrews County on the high plains exhibit distinct color differences from other high plains specimens. The ventral color pattern consists of diffuse but very light irregular spotting. Laterally, the rows of spots are two in number. Other

high plains specimens have moderate to heavy ventral blotching, which is more evenly distributed. The lateral spot rows are predominantly three in number.

New Locality Records.—The following is a list of new county records for *Sistrurus catenatus* in Texas. Most records are validated by specimens (catalogue numbers in parentheses) deposited in the collection of Texas Technological College:

HIGH PLAINS.—*Andrews Co.*: 14.2 mi. SW Andrews (1746); 23.2 mi. NE Kermit (1800). *Hemphill Co.*: Definite sight record 8 mi. NE Canadian, specimen lost. *Lipscomb Co.*: 1.7 mi. SW Higgins (2201). *Roberts Co.*: 33.6 mi. N Pampa (2208); 14.1 mi. NW Miami (2205).

ALONG CAPROCK.—*Crosby Co.*: Near Ralls (20). *King Co.*: 3.3 mi. E Dumont (1805); 5.9 mi. S Guthrie (1806); 7.7 mi. E Guthrie (1820); 5 mi. W Guthrie (896).

LOW PLAINS.—*Shackleford Co.*: 7.4 mi. N Albany (1459); 7.4 mi. N Albany (1460); 8 mi. N Albany (1461); 11.5 mi. N Albany (1462); 4.4 mi. N Ft. Griffin (1670); 5.4 mi. N Albany (1672). *Throckmorton Co.*: 5.1 mi. W Woodson (1463); 5.6 mi. W Woodson (1464); 4.8 mi. W Woodson (1465); 6 mi. S Throckmorton (1466); 7.7 mi. W Woodson (1467); 6.5 mi. W Woodson (1468); 10.4 mi. N Ft. Griffin (1669); 7 mi. W Woodson (1671); 14.7 mi. N Ft. Griffin (2262).

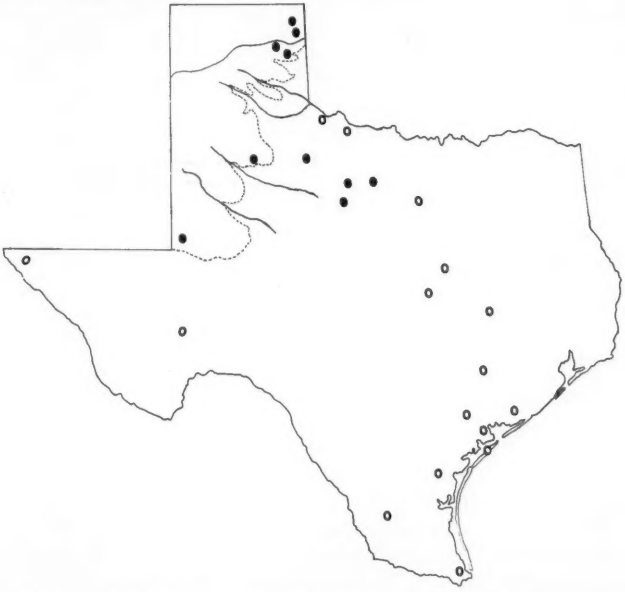

Fig. 1.—Map of Texas showing locality records for *Sistrurus catenatus*. Open circles are literature records; solid circles are based on specimens in Texas Technological College collections. The dotted line represents the position of the Caprock separating the low plains to the east from the high plains to the west and northwest.

TABLE 1.—Variation in 23 specimens of *Sistrurus catenatus* from northwest Texas.

Character	High Plains		Along Caprock		Low Plains	
Scale Rows	23-2		23-1	25-3	24-2	26-4
	24-2		24-1		25-8	
	149-1		144-1	157-1	141-1	150-2
	151-1		146-1		142-1	151-2
Ventrals	153-1		150-1		143-1	153-1
	154-1		151-1		146-2	155-1
					148-1	159-1
						159-1
	♂	♀	♂	♀	♂	♀
	30-1	26-2	28-1	26-2	27-1	24-2
		27-1	29-1		29-1	24-1
Caudals (paired			32-1		30-3	26-1
scales included)					31-1	28-2
					32-1	
					33-1	
	11-2		11-1	15-1	11-2	14-3
Infralabials	12-1		12-2		12-3	
	13-1		14-1		13-6	
	11-1		12-2		11-3	14-3
Supralabials	12-1		13-2		12-2	
	13-2				13-7	
Dorsal Blotches	35-1	42-1	33-1		33-2	38-2
(first on neck to	37-1		34-1		34-1	39-3
point above anus)	40-1		35-1		35-1	40-1
			36-2		36-1	41-1
						42-2
Lateral Blotches	34-1		31-1		33-2	38-3
(first on neck to	38-1		35-1		34-1	39-2
point above anus)	40-1		36-2		35-2	42-1
	42-1				37-1	43-2
	♂	♀	♂	♀	♂	♀
	8-1	4-1	6-1	5-1	6-1	5-2
Tail Bands		6-2	8-1	6-1	7-3	6-2
			10-1		8-4	7-2
					10-1	
	♂	♀	♂	♀	♂	♀

This paper has resulted from a study of the herpetofauna of northwest Texas conducted under a grant to Tinkle by the Texas Technological College Research Fund to which we express appreciation for support. We also wish to thank the following students at Texas Technological College for help in the field: Sumner Dana, William Voss, Irvin Patterson, Jerry Gerald, Dan McGregor, and Don McGregor.

LITERATURE CITED

BROWN, BRYCE C. 1950. An Annotated Check List of the Reptiles and Amphibians of Texas. Waco, Baylor Univ. Press, XII + 257.

FOUQUETTE, M. J., JR. AND H. L. LINDSAY, JR. 1955. An ecological survey of reptiles in parts of northwestern Texas. Texas Jour. Sci., 6(4):412-421.

GLOYD, HOWARD K. 1940. The Rattlesnakes, Genera *Sistrurus* and *Crotalus*. A study in Zoogeography and Evolution. Chicago Acad. Sci. Sp. Publ. no. 4, vii, 266 p., 10 text fig., 22 maps, 31 pl.

———. 1955. A review of the massasaugas, *Sistrurus catenatus* of the southwestern United States. Bull. Chicago Acad. Sci., 10 (6):83-93, 1 fig.

STRECKER, JOHN K. 1915. Reptiles and amphibians of Texas. Waco, Baylor Univ. Press, 18(4):82.

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Toxicity of Copper for Frogs

HAROLD M. KAPLAN AND LORETTA YOH

The toxicity of copper for ectotherms, particularly fish, has been extensively studied, even from a quantitative standpoint; much less is known about frogs exposed to similar conditions.

Directives against placing frogs in water containing heavy metals are scattered in the literature. The warnings are possibly based upon empirical findings since we have searched unsuccessfully for quantitative evidence. The present study seeks to establish an approximate numerical value for the concentration of copper in solution at which a frog can live indefinitely without harm.

MATERIALS AND METHODS

Grossly healthy frogs of both sexes and of similar size belonging only to *Rana pipiens* were studied. They were held uncrowded, i.e. one or two frogs in a clean clear plastic 7" × 12" container, with the solution changed every second day.

Since frogs are apt to be kept at different temperatures for specific experimental purposes, and since the toxicity may possibly vary with differential absorption of drugs at various temperatures, the tests were conducted at three different environmental temperatures. The tanks were left (1) in a cold room at 6°C.; (2) in an air-conditioned room at 20°C.; or (3) at a room temperature of 26°C.

The frogs were fed on alternate days, except for the animals at 6°C. which were unfed.

A copper sulfate solution in distilled water was successively diluted to several lower concentrations and each group of frogs was placed in a single concentration of solution. The fluid level in the containers was kept at approximately one inch in height. The range of concentrations selected was determined by trial and error.

The behavior and general condition of the frogs were observed during the tests and the duration of survival was recorded. Observations were arbitrarily terminated after 30 days in animals surviving without any grossly describable changes.

Some untreated controls in tap water only were used to determine whether the copper concentration ordinarily found in water has any harmful effect upon frogs.

Because the rapidity of the toxic effect may possibly vary with the acidity of the solution, which would have some bearing on the reduplication of our results, pH values at 26°C. were determined electrometrically. They are listed in Table 1 for each concentration.

Experimental Data

Copper sulfate was variably toxic at all temperatures in concentrations of about 0.0015 per cent and greater. Curves were drawn from the data in Table 1, for concentration vs. survival time, at these temperatures. The curves indicated that in any concentration allowing survival for a week or more, there was a tendency for the frogs to survive longer with increasing temperature. It was thought unnecessary to present these curves in this paper.

Untreated control frogs kept at similar temperatures in tap water survived indefinitely.

The concentration of copper in tap water in our laboratory was determined by an electrolysis method (Furman, 1939). The water contained 0.0005 per cent of free copper, which is an approximation, chiefly because the amount of copper in tap water varies somewhat from day to day due to variations of the source and other factors.

Frogs in high concentrations of copper sulfate tended to increase their cutaneous output of mucus. The compound crystallized within the mucous covering. The eyes became irritated. Blinking and rubbing of the eyes with the forelimbs occurred at first and ceased after the first day.

Four hours after immersion of several frogs in 0.1 per cent copper sulfate, the heart rate increased from 11 to 13 beats/minute above normal. Some time before death, it gradually decreased to minimal values of 6 to 11 beats/minute below normal.

The heart rate was also observed in several frogs at lower concentrations. At 0.025 per cent it progressively decreased to a low

of 6 to 25 beats below normal by 48 hours.

At concentrations of 0.005, 0.0025 and 0.002 per cent, there was a lesser but characteristic tendency of the rate to decrease.

At 0.0015 per cent, the rate was normal in the first 10 days, decreased in the second 10 days, and then returned to almost normal in the third 10 days of observation in all survivors.

The heart became arrhythmic in some animals in the last few days of life. This was most obvious in the higher concentrations. In the 0.0015 per cent solution, the heart was rhythmic in all survivors.

Within 48 hours after immersion in 0.1 or in 0.025 per cent solutions, the respiratory rate decreased from 18 to 22 cycles/minute below normal in most cases.

Neuromuscular coordination was disturbed and reaction time was noticeably delayed within 48 hours, especially in the lethal concentrations. At 72 hours, any frogs surviving in the higher concentrations were flaccid and did not move even when stimulated. Most deaths occurred with the limbs extended. The posture of the frogs changed in 24 hours in the 0.1 per cent solution to a crouching "defensive" type. This was seen at 24 to 48 hours in the 0.025 per cent solution.

By plotting the number of animals dead against the concentration, the LD_{50} could be obtained by interpolation. This value was 0.0016 per cent, at 20°C.

Quantitative survival data are listed in Table 1.

Discussion

The present results are applicable only to *R. pipiens*, which is a very common species used in experimental work. Copper is said to be especially toxic for *Xenopus laevis*.

There is apparently no danger to *R. pipiens* from copper in tap water, even with indefinite exposure. It is possible that in some localities the copper content of water is high enough to be toxic.

The data presented refer only to prolonged immersion. No conclusions should be drawn about short exposures. For example, Kaplan and Licht (1955) recommended the immersion of grass frogs in 1.2 per cent copper sulfate, for a period not exceeding one hour as an aspect of the therapy of red leg disease. Allowing frogs to swim several minutes in 1:2,000 copper sulfate solution is suggested by Kaplan (Unpublished Data) in the treatment of *Saprolegnia* infestation of grass frogs.

The temperature of the storage water makes a small difference in the toxicity of copper for frogs. The animals seem to survive a bit longer when kept at higher temperature. No reasons for this are presented.

TABLE 1.—The viability of *Rana pipiens* in varying concentrations of aqueous copper sulfate solutions.

Conc. $CuSo_4$ in %	Room temperature in °C	No. of frogs used	No. of frogs dead at following days (1-3)	6	9	12	15	18	21	24	27	30	Indefinite survival
0.1	6	10	10										
pH 4.9	20	14	14										
	26	10	10										
0.025	6	10	8	2									
pH 5.2	20	14	9	5									
	26	10	7	3									
0.005	6	11	7	4									
pH 5.5	20	11	4	4	3								
	26	11		7	4								
0.0025	6	14	9	3	2								
pH 5.6	20	12	8	2	2								
	26	14	3	4	6	1							
6	13	3 2 1	5	2									0.002
pH 5.6	20	13		2	3	5	1	2					
	26	13				5	3	5					
0.0015	6	17						2	4	1			10
pH 5.6	20	17							3	1	3		10
	26	16									2		14
0.001	6	8											8
pH 5.5	20	8											8
	26	8											8
0.0005	6	8											8
pH 5.6	20	8											8
	26	8											8
0.0003	6	8											8
pH 5.7	20	8											8
	26	8											8
0.0001	6	8											8
pH 5.6	20	8											8
	26	8											8

The mechanism of action of copper is uncertain. Jones (1937) said that in the minnow, *Phoxinus phoxinus,* asphyxiation was produced following coagulation of the gill mucus. Copper may precipitate proteins on the surface of the animal, or it may poison the intracellular oxidation catalysts (Pyefinch and Mott, 1948). Metals, also, are most active in an ionic form, and the effect of free electrical charges must be considered.

SUMMARY

Frogs exposed continuously, over a range of environmental temperatures, to aqueous solutions of copper sulfate exceeding

0.001 per cent concentration are not apt to survive. The duration of life decreases with increasing concentration of the copper sulfate.

The small concentration of copper ordinarily existing in tap water has no measurable effects upon *Rana pipiens*.

Literature Cited

Furman, N. H. 1939. Scott's standard methods of chemical analysis, D. Van Nostrand Co., Inc., Princeton, New Jersey, 5th ed., 2:2080-1.

Jones, J. R. E. 1937. The toxicity of dissolved metallic salts to *Polycelis nigra* (Muller) and *Gammarus pulex*. Jour. Exp. Biol. 14:351-363.

Kaplan, H. M. and L. Licht. 1955. Evaluation of chemicals used in control and treatment of disease in fish and frogs caused by *Pseudomonas hydrophila*. Amer. Jour. Vet. Res. 59:342-344.

Pyefinch, K. A. and J. C. Mott. 1948. The sensitivity of barnacles and their larvae to copper and mercury. Jour. Exp. Biol. 25:276-298.

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Notes

ON THE ORIGINAL DESCRIPTION OF *SCELOPORUS UNDULATUS*.—Schmidt (1953, Check List of North American Amphibians and Reptiles, p. 126) cites the original description of *Sceloporus undulatus* as *Stellio undulatus* Latreille (1802, Histoire Naturelle des Reptiles, 2:40). However, according to Sonnini and Latreille (*loc. cit.*), "Daudin doit la connoissance et la description de cette nouvelle espèce, au naturaliste Bosc." In checking the older literature it was further noted that Daudin himself (1805, Hist. Nat. Rept., 3:384) also stated that Monsieur Bosc had sent him (Daudin) the manuscript name and description (*Lacerta undulatus*), which was subsequently sent to Latreille for publication (*loc. cit.*). Among the earlier workers who credited Bosc with the original description were: Holbrook (1842, North American Herpetology, 2:73) and Boulenger (1885, Cat. Lizards in the British Museum, 2:227). The change apparently occurred when Cope (1900, Crocodilians, Lizards, and Snakes of North America, 370) attributed the name and original description to Latreille. The correct citation should thus be *Sceloporus undulatus* Bosc, in Latreille.—Benjamin H. Banta, *California Academy of Sciences, San Francisco 18, California.*

HERBIVOROUS FEEDING OF *PHRYNOSOMA PLATYRHINOS* IN SOUTHERN NEVADA.—The food of the Desert horned lizard, *Phrynosoma p. platyrhinos*, is known to include ants and other terrestrial insects, but herbivorous feeding has not previously been reported.

In 1955, I obtained five specimens of *P. platyrhinos* in southern Nevada. While preserving a specimen, I slit the stomach lining, releasing several small, reddish orange-colored, oval-shaped objects. Later examination of these bright-colored objects disclosed that they were the fleshy fruits of the desert shrub, *Lycium Andersonii* Gray. I am indebted to Mr. Thomas Howell of the California Academy of Sciences Botany Department for this determination.

The stomachs of all *P. platyrhinos* specimens obtained were examined; the results are given in Table 1. The abbreviation SU refers to the reptile catalog of the Natural History Museum. Stanford University. Collecting data for the specimens examined, all from the state of Nevada, are given in Table 2.

I believe that these horned lizards must have climbed up into the branches of the *Lycium* bushes and nipped the ripe berries off the stems, for all berries examined from stomach contents still had the calyces attached. Had the lizards picked up the berries from

TABLE 1

Lycium BERRIES

SU number	number	Per cent volume	Other stomach contents
20151	6	50	2 beetles 2 caterpillars 3 ants
20152	28	80	remains of beetles, ants, caterpillars
20153	6*	95	insect remains
20154	14	80	beetles, ants
20156	2	20	beetles, ants

*contained ten berries in small intestine

TABLE 2

Collecting data for the specimens examined, all from the State of Nevada.

SU number	Locality	Elevation	Time	Date (1955)
20151	Esmeralda County, 6.2 miles south southeast Goldfield on U. S. Highway 95	5,300'	09:53	June 17
20152	Esmeralda County, Gold Point	5,500'	11:10	"
20153	Nye County, Sarcobatus Flat, 7.7 miles south southwest Stonewall Pass	4,800'	14:45	"
20154	Esmeralda County, 7.7 miles west U. S. Highway 95 and dirt road 4.2 miles south southeast Stonewall Pass	5,700'	15:40	"
20156	Esmeralda County, 7.2 miles northeast Nevada-California state boundary on Nevada Highway 72	4,370'	06:04	June 19

the ground, most likely the calyx would not have been attached. All berries examined were nipped off at the flower stalk.—BENJAMIN H. BANTA, *California Academy of Sciences, San Francisco 18, California.*

A TECHNIQUE FOR THE PREPARATION OF TURTLE SHELLS.—On many occasions dead turtles are avoided in the field by collectors. This is usually due to the undesirable odor of advanced stages of decay. A method for obtaining useful material from such individuals is described herein.

The turtle is placed in a plastic bag in the field. When the bag is secured with a rubber band or knot the odor is confined while the turtle is in transport. In the laboratory the bagged animal is placed in a deep freeze to inhibit further decay. Freezing also limits the odor of the specimen when it is later worked on, and enhances the removal of the flesh from the bones. If a field label is placed in the bag at the time of collection, the specimen need not be directly handled again until it is processed. Time of storage in this manner is indefinite. Frozen material may be processed in a number of ways. One rather satisfactory method for osteological work is described below.

Allow the animal to thaw slightly, until a scalpel may be inserted through the skin, just under the shell into the body cavity. Since the periphery thaws first, the area under the shell is workable while the rest of the body remains frozen. For a turtle of 6-8 inch plastral length the time required is about one hour.

An incision is made at the junction of the skin and the shell. This follows the contour of the shell opening and is done anteriorly and posteriorly. A keyhole or other similar single-blade saw is now inserted through the incisions. The pectoral and pelvic girdles are severed above and below. At the same time the articulations of the cervical and caudal vertebrae to those of the shell are severed.

A scalpel is again used and the body of the turtle is separated from the shell in much the same way that one would core an apple. By keeping the deep cuts adnate to the shell, no damage is done to the internal organs.

After coring, the whole body usually slips readily from the shell through the anterior opening. The frozen flesh, due to the loss of natural elasticity, cuts more readily than unfrozen. Since only a minimal amount of the turtle (that of the periphery) has thawed, the odor has been alleviated during the work.

The shell itself is readily cleaned. Usually an elastic membrane remains on the inner surface. This pulls out easily and extraneous bits of flesh come with it. If boiling of the shell, skull or bones is desirable, allow the parts to return to room temperature before placing in warm water. A sudden change of temperature from the frozen condition increases the chance of suture separation and the bones fall apart. The frozen body of the turtle is intact and may be dissected, preserved, or returned to the freezer for later study

The method described has been used satisfactorily on members

of the genera *Gopherus, Clemmys, Chrysemys, Sternotherus, Terrapene, Dierochelys, Chelydra,* and *Emydoidea.*

The value of this method of handling dead individuals lies in the facts that: (1) it alleviates the objectionable smell of decaying animals; (2) a turtle may be removed from its shell with less disturbance of the internal organs and shell than is possible with other methods; (3) and parts that are removed may be worked on with greater facility in the frozen or semi-frozen condition as opposed to the unfrozen state.—JAMES A. MACMAHON, *Department of Biology, University of Notre Dame, Notre Dame, Indiana.*

THE GROWTH AND SIZE OF *SIREN LACERTINA.*—In early March of 1954, at the request of Mr. Roger Conant and Mr. F. A. Ulmer, Jr., of the Philadelphia Zoological Garden, I collected two specimens of *Siren lacertina* which I forwarded to them alive. These specimens were immediately sent on exchange to Dr. H. Mendelssohn of Tel-aviv University. I did not measure the specimens when I collected them but Dr. Mendelssohn informs me they were very close to 350 mm. long when he received them in late March of 1954. In the summer of 1960 one of them developed an infection of *Saprolegnia* which spread rapidly and did not yield to treatment. This individual died in late September of 1960. When measured at death, it was 950 mm. long, a length that it had practically attained in 1958. This is an increase of approximately 600 mm. between March 1954 and September 1958. At my request Dr. Mendelssohn measured the surviving specimen in November of 1960, at which time it has a length of 900 mm. and a maximum body circumference of 225 mm.

Dr. Mendelssohn also kindly sent to me for examination four of the dorsal vertebrae of the specimen that died. These vertebrae, while larger than typical *Siren* vertebrae, are not particularly massive. The largest one has a centrum length of 15.5 mm., a maximum height of 19.2 mm., and a width at the narrowest place between the anterior and posterior zygapophyses of 9.8 mm.

I do not know on what basis the late Professor Bishop (Handbook of Salamanders, 1947) listed the maximum size of *Siren lacertina* as 915 mm. The four largest adults in the University of Florida collections range in length from 561 mm. to 613 mm. with an average length of 588 mm. The specimen mentioned by Bishop in his Handbook of Salamanders of 798 mm. is, in fact, a very large individual; the largest I have ever measured had a total length of 728 mm. The 950 mm. individual that was raised in captivity in Tel-aviv seems to be unquestionably the largest individual recorded, and certainly, it attained a length much greater than most individuals attain in nature in the Southeastern United States.—COLEMAN J. GOIN, *University of Florida, Gainesville.*

BIRTH SEASON AND YOUNG OF *CROTALUS SCUTULATUS* AND *AGKISTRODON CONTORTRIX LATICINCTUS*.—On August 11, 1958, I observed many small individuals of *Crotalus scutulatus* abroad on State Highway 86 near Robles Junction, Pima County, Arizona. Two trips over the section of highway from three to seven miles west of Robles Junction yielded seven specimens, three of which were preserved. These three measure 283, 277 and 265 mm. total length. Their umbilical scars are deeply indented. They had shed for the first time since none had a prebutton. Klauber (1937. Occ. Pap. San Diego Soc. Nat. Hist. 3) estimated the average length at birth in this species as 275 mm. and stated that eight to ten days elapse between birth and the first ecdysis, at which time the prebutton is lost. The specimens at hand are apparently young-of-the-year that were at least eight days old when caught. An additional pertinent record is that of Gloyd (1937. Bull. Chi. Acad. Sci. 5:5) who captured a 250 mm. *C. scutulatus* at Ajo, Pima County, on August 14, 1930.

Klauber (1956. Rattlesnakes. p. 692) has indicated that rattlesnakes living in a climate like that of southern Arizona should bear young earlier than the average mid-September peak of species living in higher latitudes. Klauber gives birth dates for *C. scutulatus* of August 22, September 18 and 20, but these do not appear to characterize the birth season of this species in southern Arizona. Gloyd's record and the abundance of young *C. scutulatus* on August 11, 1958, indicate that the season is well advanced by mid-August and may start before the first of August.

A 326 mm. *Agkistrodon contortrix laticinctus* captured near Stillwater, Payne County, Oklahoma on April 6, bore young on July 10, 1960. The six young snakes, all males, were born before 8:00 a.m. and remained in their sacs until late that afternoon, the last emerging at 5:30 p.m. The remarkably uniform scalation of the brood is summarized here: dorsals, 22-22 in all; ventrals, 147(1), 148(2), 149(2), 150(1); caudals, 44(2), 45(1), 46(2), 47(1); umbilical scar length, 4(3), 5(2), 6(1) and location (before anal plate), 11(1), 12(2), 13(2), 14(1). The total lengths range from 206 to 222, average 214 mm. The most striking characteristic was their color. Instead of the rich, rusty brown tones of the adult copperhead the young are colored entirely in shades of gray, with the tail tip yellow as often mentioned in the literature.

Birth dates for this subspecies recorded by several authors (Allen, 1955, Herpetologica 11:228, Carpenter, 1958, Herpetologica 15:115, Wright and Wright, 1958, Handbook of Snakes, p. 908) are August 16, 17, 20, 24 and September 6 and 9. The birth season is now known to be spread over a two month period from July to September. Brood sizes range from one to eleven, average 5.2 (14 records). Average length at birth (20 records) is 234.5 mm.—CLARENCE J. MCCOY, JR., *University of Colorado Museum, Boulder.*

THE DISTRIBUTION OF THE MOLE SNAKE IN MARYLAND—The mole snake, *Lampropeltis calligaster rhombomaculata* (Harlan), has been found with considerable regularity in certain parts of the inner Coastal Plain of Maryland. Its apparent absence from other Coastal Plain counties led local workers to view its range as a diagonal finger-like projection running from the Potomac River near Washington to northern Anne Arundel County, including the southeastern periphery of Montgomery County, the upper half of Prince George's County, and the District of Columbia. Specimens were also known from the Eastern Piedmont, in Montgomery County and the District. The recent discovery of this snake in two other Coastal Plain counties necessitates a change in past opinion and clarifies its distribution within Maryland, the northern limit of its range.

Two adult *rhombomaculata* were found DOR on October 15, 1960, just south of Pomfret, Charles County, by Duke Campbell, Richard Franz and myself. They were within a quarter mile of each other on Md. 227 approximately 1.7 miles north of its junction with Md. 225, in a heavy oak association. The first had been dead for at least two days, and the second for approximately 4-6 hours. These specimens are Nos. R3013-14 in the collection of the Natural History Society of Maryland (NHSM).

On November 1, 1960, a third Charles County specimen was found DOR on Md. 381 in the Cedarville State Forest by Robert S. Simmons and Duke Campbell. This snake, freshly killed and in excellent condition, was found at 1 p.m. and is in the collection of Dr. Simmons. He has indicated that this is probably the latest recorded date for an active specimen of this snake in Maryland.

Following the October 15 discovery, Campbell and I devoted October 16 to a day and night search of the likely collecting spots in St. Mary's County. Although we found 29 snakes of nine species, no mole snakes were found. In late October a letter, which added to our understanding of this snake, was received from Karl Krumke III of Washington D. C., who with his son, spends most of every spring and summer at Piney Point, St. Mary's County. With the letter was a list of snakes of this locality including a *rhombomaculata* verified by Dr. Doris Cochran of the United States National Museum. Mr. Krumke also informed me of a specimen found DOR near Leonardtown on October 11 or 12. Thus, I feel that the mole snake is obviously an indigenous resident of St. Mary's County.

Despite the fact that it has not yet been taken in Calvert County (most of which is a peninsula), the range of *rhombomaculata* apparently encompasses the entire inner Coastal Plain south of Baltimore City and encroaches on the Piedmont in the Potomac River Valley and vicinity.—JOHN E. COOPER, *Department of Herpetology, Natural History Society of Maryland, and Baltimore City College, Baltimore, Md.*

SOME NOTEWORTHY RECORDS FROM EASTERN NEW YORK.—Knowledge of many of our less common or more elusive reptiles and amphibia is extremely limited, even in heavily populated and well studied areas such as eastern New York. The following records, accumulated over several years, seem sufficiently noteworthy to be of general interest to herpetologists.

Ambystoma opacum: Accounts of the range of this species usually indicate its occurrence as far north as Greene county, apparently on the strength of a specimen collected in 1851 at Coxsackie. All modern published records of which we have knowledge, however, have been on Long Island or in the area from Newburgh, Orange county, south along the Hudson valley. We have three records from Ulster county, which lies between Orange and Greene counties. The first was collected at the Ashokan Dam, on Sept. 11, 1940, by George B. Wilmott. The second was found near Port Ewen, also by Wilmott. The third was taken at Woodstock, July 15, 1960, by Ronald Koster. These localities, although about 25 miles south of the Consackie locality, are some 35 miles to the north of the Newburgh area.

Acris c. crepitans: Various authors give Long Island and southeastern New York as the northern limit of this species. On July 7, 1959, several specimens were taken from Third Binnewater Lake, five miles southwest of Kingston, Ulster county, by H. and I. Dunbar, F. Hough, D. Smiley and G. B. Wilmott. Two were given to the New York State Museum and Science Service in Albany, and one has been kept alive for 18 months. Early and late dates for this species at this locality have been May 19, 1960, and Sept. 12, 1959.

Clemmys muhlenbergi: The bog turtle is so scattered in its distribution that evidence of additional populations is significant. The species was reported from Albany county by Bishop (Copeia 125:119, 1923) as occurring in Vly Creek Swamp. On May 16, 1958, a specimen was collected from Meadowdale Bog, a small marshy area bordering Black Creek and lying some two miles northeast of Altamont, Albany county, and about a mile to the north of Vly Creek Swamp, in a different drainage. Another specimen was found dead on the road at this same point in May 1960 by Margaret M. Stewart. This population could well have come as an offshoot of the Vly Creek Swamp population reported by Bishop.

In Ulster county an empty shell of a bog turtle was found in a quaking bog in the headwaters of Black Creek, near Esopus, on Sept. 17, 1958, by Daniel Smiley.—ALLEN H. BENTON AND DANIEL SMILEY, *State University of New York, Albany, N. Y., and Mohonk Lake, New York.*

CANNIBALISM IN THE SALAMANDER, *PLETHODON CINEREUS*.—Murphy (Copeia, 1918:8), Smallwood (Copeia, 1928:89-98), Hamilton (Copeia, 1932:83-86), and Jameson (Copeia, 1944:145-147) have all studied the food habits of *Plethodon cinereus* and found that it eats a variety of small invertebrates. Other comments by various authors substantiate this general statement. It appears that this species may eat anything it encounters within a suitable size range which is active enough to attract the salamander's attention by its motion. Thus it is not surprising to find that cannibalism occasionally occurs, although it has not been previously reported in the literature for this species. However, Piersol (Trans. Roy. Canad. Instit. 1914:121-126) mentions a captive female swallowing and later regurgitating two eggs.

During the summers of 1951, 1952, 1954, and 1955, stomach contents of 317 individuals of *P. cinereus* collected in the vicinity of The University of Michigan Biological Station were examined by students. Of these, two specimens had each eaten a young individual of the same species. This very low incidence (0.6 per cent) indicates that cannibalism occurs rather infrequently under field conditions and hence probably does not exert a great influence on natural populations.

An unusual instance of cannibalism in this species was noted under laboratory conditions. Approximately 100 salamanders were collected during the summer of 1957 in The University of Michigan Biological Station area and subsequently placed in a large terrarium to be kept for experimental purposes. On November 1, 1957, an individual of the black color type was removed from the terrarium and examined because of its plump appearance. On being handled, it regurgitated a salamander of the striped color type. The head and some of the tail of the prey had been partly digested. The remaining part was 46 mm. long. The length of the predatory salamander was 42 mm. from snout to front of hind leg (89 mm. total length). The prey was probably swallowed head first as the tail was the first part to emerge at regurgitation.

Whether such ambitious gastronomic feats occur in nature is not known, and it is possible that the crowded conditions of the terrarium in which the animals were kept may have been responsible for this unusual occurrence.—HAROLD HEATWOLE, *Department of Biology, University of Puerto Rico, Rio Piedras, P. R., and* FREDERICK H. TEST, *Department of Zoology, University of Michigan, Ann Arbor, Michigan.*

NOTES ON A BITE OF THE BROAD-BANDED COPPERHEAD, *ANCISTRODON CONTORTRIX LATICINCTUS* GLOYD AND CONANT.—About 1:15 a.m. on July 18, 1958 a male *Ancistrodon contortrix laticinctus* measuring 57.4 cm. from Marshall

County, Oklahoma inflicted a slight wound on digit III of the author's right hand. The bite was inflicted through a canvas collecting bag with only one fang slightly penetrating the surface of the skin. No medical action was taken. Approximately three hours later, at 4:10 and again at 4:45 a.m., slight nausea along with some vomiting was noted. Later the finger became swollen to the point where only slight movement was possible, and that afternoon the dorsal (or extensor) surface of the hand became swollen. During the evening slight pains were noticed in the forearm and they persisted through to the evening of the 19th. The other four digits retained their normal proportions and flexibility. There was no discoloration of the skin at any time. All pain and swelling disappeared by the end of the third day.

Minton (1953, Copeia (4):212) states that the effect of the bite depends on the toxicity of the venom and the amount injected, although other factors such as the depth and location of the wound may be important. He finds (*op. cit.*:215) no direct relation between toxicity and health factors, but there was variation among individual copperheads.

Had the snake been able to bite under natural conditions without the collecting bag acting as a partial shield or if both fangs had penetrated, the effect of the wound might have been different.—Richard A. Diener, *Department of Zoology, University of Oklahoma, Norman.*

NORTHERLY RANGE EXTENSION FOR THE SMOOTH EARTH SNAKE, *VIRGINIA VALERIAE*.—A live specimen of the smooth earth snake, *Virginia valeriae elegans* Kennicott, was collected in Tippecanoe County, Indiana, nine miles west of the City of Lafayette (NW¼ SW¼ SW¼ T23N R5W 2PM) on 28 October 1960. The snake was found crawling across a trail in a second-growth mixed hardwood stand. It has 17 rows of dorsal scales (weakly keeled posteriorly), 128 ventrals, 33 caudals, 2 internasals, 6 supralabials, 2 postoculars, an over-all length of 278 mm., and a tail length of 43 mm. Its tail is narrow and tapering, suggesting that it is a female. The specimen has been added to the Purdue Wildlife Laboratory Collection (Accession No. 1-790).

Edgren and Ward (Chicago Acad. Nat. Hist .Misc. 95:1-3, 1952) reported and cited collections of *Virginia valeriae elegans* from Brown, Lawrence, Montgomery, and Parke counties, Indiana. The present specimen thus extends the known range of this snake (and of the genus) northward by about 38 miles (to 40°26'05"N lat.). The range therefore extends about 48 miles north of the southern extent of Wisconsin glaciation, a line with which Edgren and Ward associated the northern limit of the species.—Arthur H. Westing, *Department of Forestry and Conservation, Purdue University, Lafayette, Indiana.*

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